

U.S. Department of
Homeland Security

United States
Coast Guard



United States Coast Guard

Removal Action Work Plan

**USCG Atwater Facility
Detroit, Michigan**

Task Order Number HSCG83-09-J-3CL358
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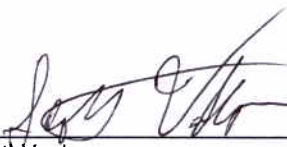
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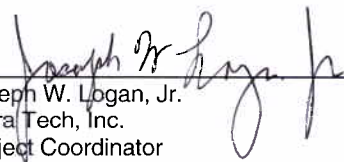
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Removal Action Work Plan

USCG Atwater Facility
Detroit, Michigan

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1. Introduction

This removal action work plan (RAWP) was prepared by Tetra Tech, Inc. (Tetra Tech) on behalf of the U.S. Coast Guard (USCG) for the USCG Atwater Facility (Site) located in Detroit, Michigan (see Figure 1 and Figure 2). It was prepared in accordance with United States Environmental Protection Agency (USEPA) Guidance for Conducting Non-Time-Critical Removal Actions Under CERCLA (Comprehensive Environmental Response, Compensation and Liability Act) and Section 300.415 of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), to address soil and groundwater impacted by arsenic, lead, and polynuclear aromatic hydrocarbons (PAHs) at concentrations above Site-specific removal action objectives (RAOs).

This RAWP is designed to be used in conjunction with other supporting documents, including the Engineering Evaluation/Cost Analysis (EE/CA) (Tetra Tech, 2012b), the project-specific Quality Assurance Project Plan (QAPP) (Tetra Tech, 2010), the QAPP Addendum (Tetra Tech, 2011b), and the Field Sampling Plan (FSP) (Tetra Tech, 2011a). Because the removal action will require field screening and collecting removal completion confirmation soil samples, this RAWP also contains some of the prescribed elements of a FSP consistent with Section 300.410 of the NCP.

Additional information relevant to this RAWP provided in the EE/CA includes the following:

- Site description and background information
- Source, nature, and extent of contamination and waste characterization
- Streamlined risk evaluation
- Applicable or relevant and appropriate requirements (ARARs)
- RAOs
- Identification of removal action alternatives and selection of removal action as the anticipated final remedy

Additional information relevant to this RAWP provided in the QAPP and QAPPA includes the following:

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- Project Management and Objectives
- Measurement and Data Acquisition
- Assessment and Oversight
- Data Review
- Chain-of-Custody Forms
- Laboratory Quality Assurance Plans and Standard Operating Procedures (SOPs)
- Laboratory Certifications

Additional information relevant to the RAWP provided in the FSP includes the following:

- Removal Confirmation Sampling
- Sample Designation System
- Quality Assurance/Quality Control (QA/QC) Procedures

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2. Plan for Removal Action

The primary objective of the proposed removal action is to protect public health, welfare, and the environment, thereby facilitating the transfer of the Site from the federal inventory to be conveyed to the City of Detroit as part of the River Walk Redevelopment project. It is the intent of USCG to conduct all response actions in a manner consistent with the NCP and consistent with Section 120 of CERCLA. As indicated in the EE/CA (Tetra Tech, 2012b), the contaminants of concern (COCs) identified at the Site are arsenic, lead, and PAHs in soil. As discussed in the EE/CA, the USCG has selected RAOs of 7.6 mg/kg for arsenic, 400 mg/kg for lead, and 2,000 µg/kg for benzo(a)pyrene equivalents (BaPEqs) based on the Michigan Department of Environmental Quality (MDEQ) residential exposure criteria. The RAOs for soil cleanup are expected to be protective of relevant exposure pathways for the current and anticipated future land use of the Site. The COCs in soil at concentrations above the RAOs have been defined horizontally and vertically as detailed in Section 2.2 of the EE/CA. (see Figure 3).

The Site monitoring wells from which groundwater samples have been collected are shown on Figure 2. Groundwater detections and laboratory analytical reports can be found in the Site Investigation (SI) Report (Tetra Tech, 2012a). Metals and PAHs have been detected in groundwater samples. When detected, concentrations of each metal and PAH were generally similar from well to well, although PAH concentrations in monitoring well MW02 were generally greater than in the other wells. For a given well, the metal concentrations in the unfiltered sample were very similar to the concentrations in the filtered sample, which indicates that the groundwater is relatively free from suspended solids. Although a few PAHs and metals were identified as COCs, all concentrations were usually less than the maximum contaminant levels (MCLs), or where MCLs were not available, less than MDEQ risk-based screening levels (RBSLs). It was concluded in the SI Report that because MCLs and RBSLs are typically used as cleanup goals and because the shallow groundwater is an unlikely source of drinking water at this site due to the City of Detroit's prohibition of drinking water wells, active groundwater remediation will not be required.

As discussed in the EE/CA, chemical-specific, location-specific, and action-specific federal statutes and regulations that are applicable or relevant and appropriate to the planned removal action are identified in Table 1a, Table 1b, and Table 1c, respectively. In addition, chemical-specific, location-specific, and action-specific federal and state guidelines identified as to be considered (TBC) are also presented in Table 1a, Table 1b, and Table 1c, respectively. Soil removal activities will be performed in

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accordance with the ARARs and with consideration to the TBC guidance, as described in the following sections.

2.1 Soil Removal Activities

Due to the limited depth and extent of soil impacts, the USCG has determined that the most cost-effective and protective remedy for the Site is removal and off-site disposal of COCs-impacted soil impacted above the RAOs. Soils with COCs impacts exceeding the RAOs are shown in Figure 3. Removal and off-site disposal of COCs-impacted soil above the RAOs is consistent with Section 300.415 of the NCP and state requirements for protecting public health, welfare, and the environment by:

- Preventing risk of human exposure through dermal contact, ingestion, or inhalation of lead-impacted soil during future use of the Site or potential construction activities on site.

The following is a detailed description of the proposed soil removal actions for the Site.

2.1.1 Site Access

The property is owned by the USCG and access is available through the USCG.

2.1.2 Site Preparation

The areas targeted for the proposed soil removal are identified on Figure 4. Prior to beginning the soil removal action, the extent of each excavation will be measured and marked with paint or stakes and survey tape. Work zones will be identified and delineated as well as staging areas for vehicles and equipment. A plan for directly loading and unloading trucks will be determined and appropriate traffic patterns identified and marked. Finally, a decontamination station for equipment and vehicles will be established outside the work zone.

2.1.2.1 Utility Clearance

In accordance with state law, the one-call utility location service (MISS DIG System, Inc.) will be contacted at least three working days prior to the removal activities. Available Site plans will be consulted to identify any existing utilities at the Site (see Figure 2). Finally, a private utility locating firm may be contracted if needed to locate and mark any utilities that have not been located with an acceptable degree of

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confidence. A record of the utility location efforts will be maintained by the oversight contractor for the project files. The planned soil removal actions will proceed only when all of these actions are complete and documented.

2.1.2.2 Historic Preservation

As described in the EE/CA, federal and state government records, including those of the National Register of Historic Places and the Michigan State Historic Preservation Office, were searched as a part of the Phase I ESA to determine if the Site had historical or cultural significance. The subject property was not identified as a historical or cultural site (Tetra Tech, 2002).

Prior to demolishing the former maintenance building and six-car garage, the USCG contacted the State of Michigan Department of History, Arts, and Libraries, whose Environmental Review Coordinator wrote on January 23, 2004 that “no historic properties are affected within the area of potential effects of this undertaking” (Appendix A).

The USCG determined that the Site has no culturally significant resources. No other evaluation was performed, and the proposed removal action is not expected to affect significant cultural or historical resources.

2.1.2.3 Endangered Species Act

As described in the EE/CA, federal and state government records were searched as a part of the Phase I ESA to determine if there are any sensitive environmental areas of significance associated with the Site, including Federal Lands Data (Tetra Tech, 2002). No sensitive environmental areas were identified within 0.125- or one-mile of the subject site.

Because of the limited habitat and urban location, no threatened or endangered species are likely to be at the site and the removal action would not adversely affect potential habitat for threatened or endangered species. Therefore, the proposed removal action is not expected to pose a risk to potential habitat for threatened or endangered species.

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2.1.2.4 Soil Erosion and Sedimentation Control

The relatively flat Site is predominantly covered with asphalt and concrete with a small grassy area. Soil erosion and sedimentation control will be applied at the Site in accordance with MDEQ Water Bureau Soil Erosion and Sedimentation Control Program, *Soil Erosion and Sedimentation Control Training Manual* (MDEQ, 2005) and Wayne County Department of Public Services, Land Resource Management Division, *Permit Procedures for Soil Erosion and Sedimentation Control* (Wayne County, 2010). Because the remediation is under CERCLA authority, it will not be necessary to obtain erosion and sedimentation control permits. However, the applicable procedures required by MDEQ and Wayne County must be followed, including preparation of an erosion and sediment control plan.

2.1.3 Site Restriction and Security

A fence with a locked gate is located along Atwater Street and a fence is located on the eastern and western sides of the property to restrict access to the site. In the event bystanders are observed approaching work areas or equipment, the oversight contractor will immediately stop work and ask the bystanders to move out of the work area. This will be done for the safety of potential bystanders as well as work crews.

2.1.4 Surface Debris Removal

Some surface debris is currently on the Site property in areas where soil excavation is planned. The Site surface debris includes concrete, old tires, scrap metal, and a parts cleaner. Prior to excavation, the Site surface debris will be removed by Tetra Tech, Inc. and transported offsite for disposal and/or recycling.

2.1.5 Soil Removal

Soil impacted with COCs at concentrations above the RAOs will be excavated and transported to an appropriately licensed and screened landfill for disposal. Site characterization sampling indicates that the COC impacts at concentrations above the RAO are confined to the near-surface soils approximately 0 to 5 feet below ground surface (bgs) (See Figure 3). In the vicinity of MW02 (see Figure 4), the depth of the excavation will be extended approximately 2 feet below the water table to remove contaminants in the smear zone in order to reduce organic contaminant concentrations in the groundwater. Water will be allowed to drain back into the excavation. A liner will be used on the ground to minimize surface contamination from the groundwater.

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Saturated soil will be mixed with the dry excavated soil to absorb free water. The excavations will remove soil in approximately 1-foot depth increments down to the total targeted depth in the areas of identified impact. The locations of proposed soil excavations at the Site are illustrated on Figure 4.

Based on the Site characterization sampling summarized in Section 3 of the EE/CA and on Figures 3 and 4, approximately 1,400 cubic yards of non-hazardous soil will be excavated and removed from the Site. These soils contain reported arsenic concentrations of up to 24 mg/kg, lead concentrations of up to 2,400 mg/kg, and benzo(a)pyrene concentrations of up to 4,510 µg/kg. The proposed soil excavations are depicted on Figure 4. Soils removed from these areas will be directly loaded onto trucks and transported in accordance with DOT regulations to the Veolia's Arbor Hills Landfill in Northville, Michigan for disposal as non-hazardous soil. As excavation progresses, soil backfill material that is screened and certified as clean prior to use will be brought to the Site, placed directly into the open portion of the excavation, and compacted in place. Compaction will not be performed in areas if hand digging is performed.

The backfill material will be compacted in accordance with the following USCG compaction requirements. Immediately following the placing, the finished mixture will be spread uniformly in a layer and brought to optimum moisture content. The loose thickness and the surface of the layer shall be such that the specified density and the required thickness shall be obtained after compaction. Compacting will be performed with steel-faced, vibrating or pneumatic-tired rollers, or other suitable compacting equipment or combinations thereof. Compacting will continue until the layer is compacted through the full depth to a field density of at least 95 percent of the maximum density at optimum moisture content tested in accordance with ASTM D 1556. In areas not accessible to rollers or compactors, compacting will be performed with mechanical hand tampers. If the mixture is excessively moistened by rain it will be aerated by blade graders, or other suitable equipment. Aeration will be performed until the moisture content of the material is that needed to obtain the required density. The surface of the layer will be finished by a combination of rolling and blading. Final surface shall be smooth and free from waves, irregularities, and ruts or soft yielding spots. In the field, proof rolling can be performed without field density testing.

In the excavation near MW02, the portion of the excavation below the water table will be backfilled with 1 x 3 stone to minimize compaction requirements. A geotextile liner will be placed over the stone before completing the backfill of the excavation.

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Based on results of the Site evaluation sampling described in the EE/CA, none of the impacted soils on site were determined to be characteristically hazardous.

An excavator with a breaker attachment will be used to remove concrete surfaces and to excavate soil. Four-axle lead dump trucks will be used to haul the concrete and soil off site.

2.1.5.1 Field Screening

To guide the effective and complete removal of soil impacted by lead at concentrations above the RAO, the removal oversight contractor will conduct field screening of soil using an Innov-X™ DELTA Premium Environmental (Model DP-4000) X-ray fluorescence (XRF) analyzer or equivalent. This model unit does not require radioisotope operator certification nor does it pose a radiation hazard, as it operates using a low power (4 Watt) excitation source consisting of an X-Ray tube with a gold (Au) or Tantalum (Ta) anode target.

After the anticipated volume of impacted soil has been removed in areas where lead concentrations exceeded the RAO, soil samples will be collected from the excavation bottom and sidewalls in these areas for XRF analysis to help define the extent of the excavations. Soil samples will be field screened according to the SOP for Innov-X™ DELTA Premium Environmental X-Ray Fluorescence Analyzer Sample Screening and the USEPA Method 6200 Ex-situ Field Screening for Lead Using XRF provided in Appendix C.

The portion of soil selected for field screening will be prepared by placing approximately 8 ounces of soil into a disposable zip locking plastic bag. Any large pieces of soil within the plastic bag will be broken into smaller pieces, and the soil will be blended to form as homogeneous a mixture as is practical. The bagged samples will be placed on a lead-free plastic work table prior to XRF screening. Each sample will be screened by placing the XRF analyzer onto the sample for 120 seconds, or as recommended by the manufacturer, to obtain comparable results among the samples. A copy of the Innov-X™ DELTA Premium Environmental XRF analyzer instruments specification sheet is included in Appendix C.

The XRF analyzer will be calibrated daily according to the project QAPP and calibration results recorded in the field log book or on equipment calibration logs. XRF analyzer results will be recorded in the field log book or on field data sheets in instrument units that are equivalent to parts per million (parts per million, roughly equivalent to mg/kg).

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If field screening indicates lead concentrations at or above 300 mg/kg or arsenic concentrations at or above 7.6 mg/kg, additional soil will be removed. The soil removal will be terminated at each location when results of the field screening indicate lead concentrations lower than 300 mg/kg and arsenic concentrations at or above 7.6 mg/kg. Once the soil removal is complete, confirmation soil samples will be collected to confirm removal of impacted soil to the RAOs. If the laboratory analysis indicates that a confirmatory sample exceeds the RAOs, additional excavation will be necessary to remove the associated soils. After the re-excavation is completed, the area will be re-sampled to verify that the RAOs are met. The sampling will be conducted according to the procedures presented in Section 2.2.

2.1.5.2 Cultural Artifacts

Federal and state government records, including those of the National Register of Historic Places and the Michigan State Historic Preservation Office (SHPO), were searched as a part of the Phase I ESA to determine if the Site had historical or cultural significance. The subject property was not identified as a historical or cultural site (Tetra Tech, 2002). The USCG determined that the Site has no culturally significant resources. No other evaluation was performed, and the proposed removal action is not expected to affect significant cultural or historical resources.

However, in the event that objects of potential historical significance are encountered, the excavation oversight contractor will stop the removal action and contact the USCG and Michigan SHPO to discuss the findings. A field determination will be made based on discussions between the involved parties as to the significance of the findings, and the planned actions will be communicated to the USCG and Michigan SHPO prior to proceeding with the soil removal.

2.1.5.3 Soil Transport and Disposal Management

The impacted soil will be live-loaded into trucks or drums during the removal action to minimize the need for stockpiling of soils. All non-hazardous waste will be sent to a local or intrastate disposal facility if possible. Debris will be removed and transported offsite for disposal preferably by recycling. Non-hazardous waste soils will be transported by the removal contractor to the Veolia's Arbor Hills Landfill in Northville, Michigan for disposal. Trucks are not required to be placarded and drums are not required to be labeled in accordance with DOT regulations. The trucks will follow a prescribed transportation route to the appropriate disposal facility.

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The USCG will review, approve, and sign all waste profile and non-hazardous waste shipping documents prior to the shipment of soil from the Site. The oversight contractor, Tetra Tech, will obtain weight tickets, tare/gross weight slips, and non-hazardous waste shipping documents from each truckload of non-hazardous waste soil transported from the Site. The volume of material removed from the Site will be recorded in the field log book in accordance with the QAPP. Certificates of disposal will be obtained from the disposal facilities. Copies of all transport and disposal documentation will be provided in the removal action completion report and will be kept on file by the USCG for a period of 3 years.

2.1.6 Shoring and Dewatering

Because the excavations are not expected to exceed 5 feet bgs, or below the water table in most areas, and only two feet below the water table near well MW02, no shoring or dewatering measures are anticipated to be needed. As reported in the SI Report, the depth to groundwater is approximately 5 feet bgs (Tetra Tech, 2012a). Therefore, excavation dewatering is not anticipated to be required.

2.1.7 Air Monitoring

Air monitoring will be performed and documented throughout the entire soil removal action due to the toxicity of the COCs in dust. Air quality will be continuously monitored with a particulate meter within the work zone according to the contractor Health and Safety Plan (HASP) provided in Appendix D using a particulate meter to monitor worker exposure to airborne particulate concentrations.

Air quality will be continuously monitored at each of the air monitoring stations, and measurements of total particulate concentration, as well as date, time, and wind direction, will be recorded on air monitoring logs or in the field log book. The frequency of the monitoring at each station will depend on the activities being conducted and the predominant wind direction. If the action levels identified in the HASP are exceeded, the oversight contractor will immediately stop work and establish a plan for reducing the dust emissions at the Site.

2.1.8 Dust Suppression

Due to the shallow depths of the proposed excavations (2.5 to 5 feet bgs) and the limited lateral extent of these excavations, dust problems are not anticipated during soil removal activities. However, if the action levels defined in the HASP (Appendix D) are

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exceeded at any time, work will be stopped and dust suppression measures will be evaluated. These measures may include, but are not limited to, spraying the excavations lightly with clean water to minimize dust emissions. Water will be supplied by a water truck.

2.2 Confirmation Sampling

Removal confirmation samples will be collected following the soil removal action using the “biased” sampling approach as described in the Section 4 of the FSP Soil and Groundwater (Tetra Tech, 2011a). There are eight excavations totaling approximately 8,400 square feet of floor space and approximately 850 linear feet of side walls. Confirmation sidewall and bottom samples will be collected from each excavation in accordance with the biased sampling approach defined in Section 4 of the FSP. A total of 43 confirmation samples are anticipated to be collected (Figure 6). If any confirmation samples are reported to contain concentrations of a COC above the RAO, over-excavation will be performed in those areas and additional confirmation samples collected as described in Section 4.3 of the FSP until the RAO is achieved in each area.

Confirmation samples will be collected in laboratory-provided containers using a decontaminated stainless steel scoop or shovel according to the SOP for *Soil Sampling* provided in Appendix B. Sample containers will be labeled with the sample location identification, date of sample collection, and intended analysis. Sample nomenclature is described in Section 8.2 of the FSP. The samples will be immediately placed on ice in a cooler awaiting transport to the laboratory by courier.

Samples will be submitted to Trimatrix Laboratories, Inc. located in Grand Rapids, Michigan for analysis of total arsenic, lead, and PAHs in accordance with the QAPP. Laboratory results will be reported on a dry weight basis. Chain-of-custody protocol will be documented and strictly adhered to in accordance with the QAPP. Appropriate QA/QC samples will be collected in accordance with the QAPP and FSP for the Site. Full Contract Laboratory Program (CLP)-type (Level 3) analytical reporting and validation will be requested for all removal confirmation samples collected from excavation side walls and bottoms.

Based on the limited depth and extent of impacted soil at concentrations above the RAOs, 43 confirmation samples are expected to be sufficient to definitively demonstrate effective and complete removal of impacted soil at concentrations above the RAO. If the excavations are expanded based on field screening results, the

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appropriate number of confirmation samples will be recalculated in accordance with the approach outlined in the FSP based on the final size of each excavation and the appropriate number of confirmation samples collected.

Confirmation samples will be analyzed for arsenic, lead, and PAHs. Confirmation sampling is based on two bottom samples per 1,000 square feet, and side wall samples at a rate of one sample per 25 linear feet with a minimum of one sample per wall. Confirmation samples have a 24-hour turnaround time.

The depths and lateral extents of removal areas where soil impacted with arsenic and lead was found at concentrations above the RAOs will be determined by results of the field screening. Bottom and sidewall samples will first be field screened using the XRF analyzer. If XRF field screening results indicate potential impacts (i.e., results greater than 300 mg/kg lead or 7.6 mg/kg arsenic), additional soil will be removed and subsequent bottom and side wall samples collected as described above. If results of the field screening are lower than the RAOs, the samples will be sent to the laboratory for confirmatory analysis.

2.3 Decontamination Procedures

Equipment in contact with the impacted soil or a significant amount of dust will be decontaminated according to the SOP in Appendix B. Reusable equipment used for soil sampling will be scrubbed using a solution of detergent and distilled water and double-rinsed in distilled water. Decontamination water will be containerized in an appropriately labeled DOT-approved 55-gallon drum, and a composite sample of the contents will be collected for waste characterization analysis. The drum will be securely sealed and remain at the work site pending receipt of laboratory results upon which the waste will be properly disposed at an appropriately licensed facility.

2.4 Site Restoration

The excavation will be filled with clean soil to match the existing grade. Based on the estimated volume of soil to be removed from the Site, approximately 1,300 cubic yards of clean material will be used to regrade the areas of excavation. The fill will be covered with grass seed to revegetate the ground surface.

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2.5 Site Survey

The final excavation limits and locations of confirmation samples will be surveyed using a global positioning system unit according to the SOP in Appendix B. The names and locations of survey points will also be recorded in the field log book. The survey data will be used to update the Site figures following the removal action.

2.6 Monitoring Well Installation

Following the soil removal and site restoration, two of the monitoring wells (MW01 and MW02) abandoned during excavation will be replaced. The new wells shall be located within 5 feet of the original locations.

Permanent monitoring wells will be installed by a HSA drilling rig or equivalent. Each well shall be 13 feet deep. Permanent monitoring wells will be constructed of 2-inch ID, schedule 40 PVC, flush-joint riser pipe, and a 10-foot long flush-joint, factory slotted well screen with end cap. The well screen will have a slot size of 0.01 inches (10 slot). Each section of well screen and riser shall be National Sanitation Foundation (NSF) approved and meet ASTM Standard A312-86a.

A silica sand pack (No. 10 to 20 U.S. Standard Sieve size) will be placed from the base of the screen to 2 to 3 feet above the top of the screen. Pure sodium bentonite pellets or chips will be installed above the sand pack to within one foot of the ground surface and allowed to hydrate in accordance with the manufacturer's recommendations. Care shall be taken during installation of the backfill materials to reduce the potential for bridging. The augers shall be pulled up slowly as the materials are allowed to settle. The depths of backfill materials will be constantly monitored during the well installation process by means of a weighted, stainless steel or fiberglass tape.

The driller will prepare a separate well construction log for each monitoring well to be submitted to the site geologist prior to the completion of field activities.

Once the monitoring well is constructed, a flush mount cover (a minimum 6-inch round security vault provided with sealing gasket to reduce the amount of water infiltration) will be cemented in place around the well. The concrete pads will be constructed around each cover with conventional Type 1 Portland cement flush with the ground surface and will measure 2 feet by 2 feet with a thickness of 6 inches. The flush mounted bolted cover will be completed level with existing grade. A locking "J-plug type" cap will be placed and secured on top of each well riser pipe to protect it from

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tampering/opening. To maintain well security, the wells will be locked using locks that are keyed alike.

Monitoring wells will be developed no sooner than 24 hours after well installation. Wells will be developed by bailing and surging, and/or by pumping, as determined by the field geologist. The wells will be developed until the discharge water is visibly clear or as determined by the field geologist (approximately 1 hour per well).

The drilling cuttings and decontamination fluids accumulated during drilling activities will be containerized in new steel 55 gallon drums (UN 1A2/Y 1.4/100). The drums shall include the barrel, a lid with a rubber gasket, a collar, and a bolt. IDW will be disposed of off-site.

A Michigan-licensed surveyor will survey the new monitoring wells. Horizontal locations for the monitoring wells will be surveyed to the Michigan State Plane Coordinate System to the nearest 0.10 foot. The vertical accuracy of the monitoring wells will be surveyed to within 0.10 foot.

2.7 Monitoring Well Sampling

Four quarters of groundwater sampling will be conducted from monitoring wells MW01, MW02, and MW04, beginning approximately two weeks after the new wells are installed and developed. Groundwater samples will be analyzed at a laboratory for PAHs, total metals, and dissolved metals, according to the Field Sampling Plan (Revision 3.0) for Site Evaluation – Groundwater and Soil (Tetra Tech, 2011).

To further evaluate biological degradation, groundwater water samples will also be analyzed using field analysis kits for alkalinity, carbon dioxide, ferrous iron, dissolved oxygen, sulfide, and sulfate and will be analyzed using field meters for pH and oxidation-reduction potential.

Purge water will be containerized in new steel 55 gallon drums (UN 1A2/Y 1.4/100). The drums shall include the barrel, a lid with a rubber gasket, a collar, and a bolt. IDW will be disposed of off-site.

The groundwater results will be compared to the following criteria:

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Chemical of Concern	Criteria, µg/L
Total Metals	
Arsenic	10
Barium	2,000
Cadmium	5
Chromium	100
Copper	1,000
Lead	2
Selenium	50
Zinc	2,400
Polynuclear Aromatic Hydrocarbons	
2-Methylnaphthalene	260
Acenaphthene	1,300
Acenaphthylene	52
Anthracene	43
Benzo(a)Anthracene	2
Benzo(a)Pyrene	0.2 (MCL)
Benzo(b)Fluoranthene	1.5
Benzo(k)Fluoranthene	1
Chrysene	1.6
Dibenzo(a,h)Anthracene	2
Fluoranthene	210
Fluorene	880
Indeno(1,2,3-cd)Pyrene	2
Naphthalene	520
Phenanthrene	52
Pyrene	140

All values are Michigan Residential RBSLs unless noted.

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3. Contractor Selection

Tetra Tech will serve as the oversight contractor for the soil removal action. Qualified subcontractors for the excavation, transport, and disposal of soil and laboratory analysis for this project have been identified based on predetermined qualifications. Sufficient resources are anticipated for the timely and cost-effective implementation of this RAWP. A project organizational chart and contact information for project personnel are provided in the QAPP.

Removal Action Work Plan

USCG Atwater Facility
Detroit, Michigan

4. Documentation and Report Preparation

The oversight contractor, Tetra Tech, will oversee the removal action subcontractor, perform the confirmation sampling activities, and document these activities. The documentation will include confirmation sample data, chain-of-custody forms, manifests, dimensions of the soil excavations, volumes of soil removed, sampling and analytical procedures, and excavation procedures. Site activities will be recorded in a field log book and on appropriate log forms as needed. Photographic documentation of the removal action and confirmation sampling will also be performed by the oversight contractor. Upon completion of the removal action and confirmation sampling activities, the oversight contractor will prepare a Removal Action Completion Report.

Removal Action Work Plan

USCG Atwater Facility
Detroit, Michigan

5. Schedule

The USCG intends to proceed with the proposed soil removal action upon receipt of USEPA concurrence that the actions taken by the USCG, including the EE/CA, this RAWP, and the QAPP, are consistent with the NCP. As described in the EE/CA, the EE/CA and the RAWP will be made available for public review for a period of 30 days. It is the goal of the USCG to be completed with the soil removal action by May 21, 2013. A project schedule is provided in Table 2.

Removal Action Work Plan

USCG Atwater Facility
Detroit, Michigan

6. References

- MDEQ (Michigan Department of Environmental Quality), 2005. Water Bureau Soil Erosion and Sedimentation Control Program, *Soil Erosion and Sedimentation Control Training Manual*. November 2005.
- MDEQ, 2007. *Operational Memorandum No. 2, Attachment 5. Collection of Samples for Comparison to Generic Criteria*. July 5, 2007.
- MDEQ, 2011. Soil: Residential, Part 201 Generic Cleanup Criteria and Screening Levels. http://www.michigan.gov/documents/deq/deq-rrd-OpMemo_1-Attachment1Table2SoilResidential_283553_7.pdf Developed under the authority of the Natural Resources and Environmental Protection Act, 1994 PA 451 as amended. March 25, 2011.
- National Oil and Hazardous Substances Pollution Contingency Plan; Final Rule. 40 Code of Federal Regulations, Part 300. March 8, 1990.
- Tetra Tech (Tetra Tech NUS, Inc.), 2002. Phase I and II Environmental Site Assessment for Detroit Atwater - Revised. December.
- TtNUS, 2010. Quality Assurance Project Plan. USCG Atwater Facility. March.
- Tetra Tech, 2011a. Field Sampling Plan (Rev 3.0). USCG Atwater Facility. April.
- TtNUS, 2011b. Quality Assurance Project Plan Addendum. USCG Atwater Facility. April.
- Tetra Tech, 2012a. Site Investigation Report for Atwater Facility. November.
- Tetra Tech, 2012b. Engineering Evaluation/Cost Analysis. USCG Atwater Facility. November.
- United States Environmental Protection Agency, 1993. *Guidance on Conducting Non-Time-Critical Removal Actions Under CERCLA*, EPA540-R-93-057. August.
- Wayne County, 2010. Department of Public Services, Land Resource Management Division, *Permit Procedures for Soil Erosion and Sedimentation Control*, May.

Table 1a. Potential Federal and State Chemical-Specific Applicable or Relevant and Appropriate Requirements and To Be Considered Guidance, United States Coast Guard Atwater Facility, Detroit, Michigan

Constituent of Concern and Media	Authority	Act	Statute, Regulation, Administrative Code, or Guidance Document	Status	Synopsis of Requirement, Criteria, or Guidance
PAHs, Arsenic, and/or Lead in Soil	Federal Advisories, Guidance, and Training Material.	NA	Recommendations of the Technical Review Workgroup (TRW) for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil. Technical Review Workgroup for Lead (TRW), Washington, D.C. (United States Environmental Protection Agency 1996.) USEPA Technical Working Group for Lead 1996	To Be Considered.	This is non-promulgated guidance that describes a methodology for assessing risks associated with non-residential adult exposures to lead in soil.
		NA	United States Environmental Protection Agency (USEPA) Integrated Exposure Uptake Biokinetic (IEUBK) Model for lead. And Adult Lead Models (ALM). IEUBK and ALM Models	To Be Considered.	These values are non-promulgated models used to assess risks associated with lead.
		NA	EPA Human Health Assessment Cancer Slope Factors (CSFs)	To Be Considered.	These are guidance values used to evaluate the potential carcinogenic hazard caused by exposure to contaminants. Were used to compute the individual incremental cancer risk resulting from exposure to carcinogenic contaminants in site media.
		NA	Reference Dose (RfD)	To Be Considered.	Guidance used to compute human health hazard resulting from exposure to non-carcinogens in site media. Were used to calculate potential non-carcinogenic hazards caused by exposure to contaminants.
		NA	Guidelines for Carcinogen Risk Assessment EPA/630/P-03/001F (March 2005)	To Be Considered.	Guidance for assessing cancer risk. Were used to calculate potential carcinogenic risks caused by exposure to contaminants.
		NA	Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens EPA/630/R-03/003F (March 2005)	To Be Considered.	Guidance of assessing cancer risks to children. Were used to calculate potential carcinogenic risks to children caused by exposure to contaminants.
	State Requirements and/or Criteria.	Natural Resources Environmental Protection Act of 1994, Public Act 451 as amended (NREPA)	Michigan Compiled Law 324, Part 201, Michigan Administrative Code (MAC) Rules 299.5706, 299.5707, 299.5718 through 299.5726, 299.5732, 299.5746, 299.5748, 299.5750, and 299.5752. MAC Rules for Part 201	Relevant and Appropriate.	These are promulgated statutes and rules associated with cleanup criteria. See Table 2 in the MAC Rules for Generic Criteria and Screening Levels for each land use category. Only Residential exposure values are relevant and appropriate.
	State Advisories, Guidance, and Training Material.	NA	Michigan Department of Environmental Quality (MDEQ) Remediation and Redevelopment Divisions (RRD) Operational Memorandum Number 1 (Part 201 Cleanup Criteria). MDEQ RRD Op Memo 1	To Be Considered.	This document is a non-promulgated memorandum prepared by the MDEQ to provide guidance on satisfying the cleanup criteria requirements under NREPA Part 201; it defines land-use categories and provides updated and interim cleanup criteria and screening levels. The attachments to the operational memorandum provide technical support documentation for the chemical physical data and algorithms used to calculate the criteria.
		NA	MDEQ RRD Operational Memorandum Number 2 (Part 201 Sampling and Analysis Guidance). MDEQ RRD Op Memo 2	To Be Considered.	This document is a non-promulgated memorandum prepared by the MDEQ to provide guidance on target detection limits and designated analytical methods; soil leaching methods; sample preservation; sampling, handling, and holding times; and the collection of samples for comparison to generic Criteria

Table 1a. Potential Federal and State Chemical-Specific Applicable or Relevant and Appropriate Requirements and To Be Considered Guidance, United States Coast Guard Atwater Facility, Detroit, Michigan

Constituent of Concern and Media	Authority	Act	Statute, Regulation, Administrative Code, or Guidance Document	Status	Synopsis of Requirement, Criteria, or Guidance
PAHs, Arsenic, and/or Lead in Air	Federal Regulatory Requirement and/or Criteria.	Clean Air Act (CAA)	42 USC 7409 42 USC 7409 40 CFR 50.12 and Appendix G to Part 50. 40 CFR 50.12 Appendix G to Part 50	Applicable.	These rules establish emissions limits for lead and describe test methods and procedures to determine emissions. The national primary and secondary ambient air quality standards for lead and its compounds, measured as elemental lead by a reference method based on Appendix G to 40 CFR 50, or by an equivalent method, are 1.5 micrograms per cubic meter (µg/m³), maximum arithmetic mean averaged over a calendar quarter. There are no ambient air quality standards for PAHs and arsenic.
	Federal Advisories, Guidance, and Training Material.	NA	None.	None.	None.
	State Regulatory Requirement and/or Criteria.	NA	Michigan Air Pollution Control Rules Part 2. Air Use Approval Exemptions R336.1290. Part 2 Air Use Approval Exemptions	Applicable.	Establishes exemption from permit to install for emission units with limited emissions. Establishes thresholds and limits by pollutant type and recordkeeping requirements.
	State Advisories and Guidance.	NA	None.	None.	None.
PAHs, Arsenic, and/or Lead in Water (Groundwater and Surface Water)	Federal Regulatory Requirement and/or Criteria.	Safe Drinking Water Act (SDWA) Act 399 of 1976 (SDWA)	42 USC Chapter 6A Public Health Section 300g. 42 USC 300g National Primary Drinking Water Standards-Maximum Contaminant Levels (MCLs) (40 CFR 141). 40 CFR 141	Relevant and Appropriate.	MCLs have been promulgated for a number of common organic and inorganic contaminants. These levels regulate the concentration of contaminants in public drinking water supplies based on health effects and technical capabilities. MCLs may also be considered relevant and appropriate for groundwater aquifers potentially used for drinking water sources. The MCL for benzo(a)pyrene is 0.0002 milligrams per liter (mg/L). The MCL for arsenic in drinking water is 0.010 mg/L. The MCL for lead in drinking water is 0.015 mg/L.
	State Regulatory Requirement.	NREPA, Act 451 of 1994	Michigan Compiled Laws Chapter 324, Part 201. MAC Rules, Groundwater Clean-up Criteria. R299.5706, R299.5708, R299.5709, R299.5710. R299.5712, R299.5716, R299.5730, R299.5732, and R299.5744. MAC Part 201 Rules	Relevant and Appropriate.	See Table1 in the MAC Part 201 Rules for Generic Criteria and Screening Levels. These values were only used in absence of MCLs. Only the reseidential exposure values are relevant and appropriate.

Table 1a. Potential Federal and State Chemical-Specific Applicable or Relevant and Appropriate Requirements and To Be Considered Guidance, United States Coast Guard Atwater Facility, Detroit, Michigan

Constituent of Concern and Media	Authority	Act	Statute, Regulation, Administrative Code, or Guidance Document	Status	Synopsis of Requirement, Criteria, or Guidance
PAHs, Arsenic, and/or Lead in Water (Groundwater and Surface Water) Continued	State Advisories, Guidance, and Training Material.	NA	RRD Operational Memorandum Number 1 (Part 201 Cleanup Criteria). MDEQ RRD Op Memo 1	To be Considered.	This document is a non-promulgated memorandum prepared by the MDEQ to provide guidance on satisfying the cleanup criteria requirements under NREPA Part 201; it defines land-use categories and provides updated and interim cleanup criteria and screening levels. The attachments to the operational memorandum provide technical support documentation for the chemical/physical data and algorithms used to calculate the criteria.
		NA	MDEQ RRD Operational Memorandum Number 2 (Part 201 Sampling and Analysis Guidance). MDEQ RRD Op Memo 2	To be Considered.	This document is a non-promulgated memorandum prepared by the MDEQ to provide guidance on target detection limits and designated analytical methods; soil leaching methods; sample preservation; sampling, and handling and holding times; and the collection of samples for comparison to generic criteria.

Notes:

NA Not Applicable.

Table 1b. Potential Location-Specific Applicable or Relevant and Appropriate Requirements and To Be Considered Requirements, United States Coast Guard Atwater Facility, Detroit, Michigan

Location	Authority	Act	Statute, Regulation, Administrative Code, or Guidance Document	Status	Synopsis of Requirement, Criteria, or Guidance
Within or directly adjacent to a protected coastal area or wetland; Federally owned property; Registered National Historic Site; Within or directly adjacent to a wildlife refuge; Within or directly adjacent to Habitat for Endangered or Threatened Species; Within or directly adjacent to stop-over for migratory birds.	Federal Regulatory Requirement.	None.	None.	None.	None.
	Federal Advisories, Guidance, and Training Material.	None.	None.	None.	None.
Activities near Great Lakes Shorelines	State Regulatory Requirement and/or Criteria.- Land and Water Management Division	NREPA	Part 323, Shorelands Protection and Management, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA). (MCL 324.32301, et seq.) Michigan Administrative Code: R 281.21, et. seq. Formerly Know as Act 245 (1970)	Relevant and Appropriate	Regulates the alteration of the soil and vegetation within a great Lakes shoreland environmental area without a permit. Regulates activities in high-risk erosion areas and flood risk areas (administered by local units of government through the federal flood insurance program) as well as environmental areas. May be applied to environmental sites of contamination that may affect the protection and management of Great Lake shoreland areas.
Within or directly adjacent to Habitat for Endangered or Threatened Species		NREPA.	Michigan Compiled Law 324 Part 365 Endangered Species Protection - Programs; cooperative agreements (Section 324.36504). Part 365 Section 324.36504 MAC R322.2.1 through 322.73.1 R322.2.1 - 322.73.1	Relevant and Appropriate.	The department may establish programs, including acquisition of land or aquatic habitat, as is considered necessary for the management of endangered or threatened species. The rules list the specific land and aquatic habit. No endangered or threatened species are likely to inhabit the site.
		NREPA.	Michigan Compiled Law 324 Part 365 Endangered Species Protection – Prohibitions; exceptions (Section 324.36505). Part 365 Section 324.36505	Relevant and Appropriate.	Actions taken or funded involving the transport and possession of endangered or threatened species are unlawful.
	State Advisories, Guidance, and Training Material.	None.	None.	None.	None.

Table 1c. Potential Action-Specific Applicable or Relevant and Appropriate Requirements and To Be Considered Requirements, United States Coast Guard Atwater Facility, Detroit, Michigan

Action	Authority	Act or Statute	Regulation, Administrative Code, or Guidance Document	Status	Synopsis
Excavation of contaminated soil and monitoring or remediation related to impacts to groundwater.	Federal Regulatory Requirement.	Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), as amended by the 1986 Superfund Amendments and Reauthorization Act (SARA).	Federal Facilities 42 United States Code (USC) 9620 42 USC 9620 Reporting Hazardous Substance Activity When Selling or Transferring Federal Real Property (Title 40 Code of Federal Regulations [CFR] 373) 40 CFR 373	Applicable.	These rules require notifications related to hazardous substances prior to the sale or transfer of real property owned by the federal government. This is applicable if a property with residual contamination is transferred.
		CERCLA as amended by the 1986 SARA.	National Contingency Plan (42 USC 9605). 42 USC 9605 National Contingency Plan (40 CFR Section 300.400 through 300.415). 40 CFR 300	Applicable.	These promulgated rules require performing a Removal Site Evaluation and a Removal Action including preparing certain documents (a Quality Assurance Project Plan [QAPP], a field sampling plan [FSP], and an engineering evaluation and cost assessment [EE/CA]), considering federal and state ARARs, soliciting community involvement, and providing notifications prior to the removal action.
		Executive Order 12580 of January 23, 1987, Superfund Implementation.	Executive Order 12580- Superfund Implementation Executive Order 12580	Applicable.	The Executive Order provides federal agencies, including the United States Coast Guard, the authority to carry out their CERCLA responsibilities under the National Contingency Plan as a lead agency.
		Resource Conservation and Recovery Act of 1976 (RCRA).	Identification and Listing of Hazardous Waste 42 USC 6921. 42 USC 6921 Identification and Listing of Hazardous Waste (40 CFR 261). 40 CFR 261 Land Disposal Restrictions 40 Part 268. 40 CFR 268	Applicable.	These regulations establish requirements for identifying any hazardous wastes that may be generated in the course of the Removal action. No wastes are anticipated to be hazardous.
		RCRA.	Standards Applicable to Generators of Hazardous Waste 42 USC 6922. 42 USC 6922 Standards Applicable to Generators of Hazardous Waste (40 CFR 262). 40 CFR 262 Standards Applicable to Transporters of Hazardous Waste (40 CFR 263). 40 CFR 263	Applicable.	These regulations establish requirements for the on-site management of any hazardous wastes that may be generated in the course of the removal action. No wastes are anticipated to be hazardous.
		RCRA.	Standards Applicable to Generators of Hazardous Waste. (42 USC 6923). 42 USC 6921 Standards Applicable to Transporters of Hazardous Waste (40 CFR 263). 40 CFR 263 Standards for Universal Waste Management (40 CFR 273). 40 CFR 273	Applicable.	These regulations establish requirements for the off-site transportation of any hazardous wastes that may be generated in the course of the removal action. No wastes are anticipated to be hazardous.

Table 1c. Potential Action-Specific Applicable or Relevant and Appropriate Requirements and To Be Considered Requirements, United States Coast Guard Atwater Facility, Detroit, Michigan

Action	Authority	Act or Statute	Regulation, Administrative Code, or Guidance Document	Status	Synopsis
Excavation of contaminated soil and monitoring or remediation related to impacts to groundwater.		Hazardous Materials Transport Act (HMTA) as Amended by the Hazardous Materials Transport Uniform Safety Act of 1990.	Transportation of Hazardous Materials (49 USC 5101-5127). 49 USC Chapter 51 Hazardous Materials Regulations - General Information, Regulations and Definitions (49 CFR 171). 49 CFR 171 Hazardous Materials Regulations - Hazardous materials table, special provisions, hazardous materials communications, emergency response information, and training requirements (49 CFR 172). 49 CFR 172 Hazardous Materials Regulations Shippers – General Requirements for Shipments and Packages (49 CFR 173) 49 CFR 173	Applicable.	These regulations establish requirements for the off-site transportation of any hazardous wastes that may be generated in the course of the remedial action. No wastes are anticipated to be hazardous.
		Clean Air Act of 1970.	National primary and secondary ambient air quality standards 42 USC 7409. 42 USC 7409 National Primary and Secondary Ambient Air Quality Standards (40 CFR 50) 40 CFR 50	Applicable.	Engineering controls are required to reduce emissions associated with excavation and transportation, as needed, to maintain ambient air quality standards.
		Clean Water Act (CWA).	Water Pollution Prevention and Control, Standards and Enforcement, 33 USC 1313 through 1314. USC 33 National Pollution Discharge Elimination System (NPDES) (40 CFR 122 – 125). 40 CFR Parts 122-125	Applicable.	This regulation establishes requirements for storm-water discharges associated with industrial activity, including waste disposal areas. Soil remediation may require consideration of storm-water regulations.
		Occupational Safety & Health Administration Act (OSHA) of 1970.	Occupational Safety & Health Administration Act (Public Law 91-596 84 STAT. 1590). PL 91-596 OSHA Occupational Safety & Health Administration (29 CFR 1910). 29 CFR 1910	Applicable.	These regulations specify requirements for health and safety protection for workers potentially exposed to contaminants during hazardous waste site remediation.
		OSHA.	Occupational Safety & Health Administration Act (Public Law 91-596 84 STAT. 1590). PL 91-596 OSHA ACT Occupational Safety & Health Administration (29 CFR 1926). 29 CFR 1926	Applicable.	These regulations specify requirements for health and safety protection for workers at construction sites.

Table 1c. Potential Action-Specific Applicable or Relevant and Appropriate Requirements and To Be Considered Requirements, United States Coast Guard Atwater Facility, Detroit, Michigan

Action	Authority	Act or Statute	Regulation, Administrative Code, or Guidance Document	Status	Synopsis
Excavation of contaminated soil and monitoring or remediation related to impacts to groundwater.	State Regulatory Requirement.	Natural Resources Environmental Protection Act of 1994, Public Act 451 as amended (NREPA).	Soil Conservation, Erosion, and Sedimentation Control Part 91 Michigan Administrative Code (MAC) R323.1702(1), R323.1709 (2), R323.1709 (3), R323.1709 (4), R323.1709 (5). Part 91	Relevant and Appropriate.	These regulations specify requirements for earth change actions including erosion and sedimentation control measures that will effectively reduce accelerated soil erosion and resulting sedimentation. These regulations require the construction of temporary or permanent control measures to remove sediment from run-off water before it leaves the site.
		NREPA.	Michigan Compiled Law 324, Part 55 Section 324.5524 Air Pollution Control. MCL 324 Part 55 MAC Air Pollution Control Rules 336.1370 through 336.1374. Michigan Air Pollution Control Rules	Relevant and Appropriate.	These promulgated statues and rules are associated with fugitive dust emissions. Dust from excavations and handling will be controlled using measures such as water sprays.
		NREPA.	Michigan Compiled Law 324, Part 111 Hazardous Waste Management Sections 324.11138 and 324.11132a. Section 324.11138 Section 324.11132a MAC R299.9208, R299.9209, R299.9212, R299.9216, R299.9217, R299.9301- 9308, R299.9311, R299.9401-9413. Part 111 Rules	Relevant and Appropriate.	Defines hazardous waste and establishes requirements for hazardous waste generators, transporters, and treatment/storage/disposal facilities. Regulates the generation, transport, treatment, storage, and disposal of hazardous wastes from site remediation. Regulates closure, post-closure, and corrective action for hazardous waste treatment, storage, and disposal facilities. Remedial action may generate hazardous waste and involve management of hazardous waste. May be applied to off-site disposal of hazardous waste. Used for determining how and in what type of disposal facility contaminated media may be removed to. May be applied to construction and operation of on-site treatment, storage or disposal units relative to requirements for characterization and handling of hazardous waste. Applied to the excavation of certain contaminated media. Note: The State of Michigan has authorization to administer Federal RCRA Subtitle C in the State. No wastes are anticipated to be hazardous.
		NREPA.	Michigan Compiled Law 324, Part 121 Sections 324.12103, 324.12109. Part 121 Section 324.12103 Part 121 Section 324.12109	Relevant and Appropriate.	These are promulgated statues and rules associated with liquid industrial waste management, such as decontamination fluid.

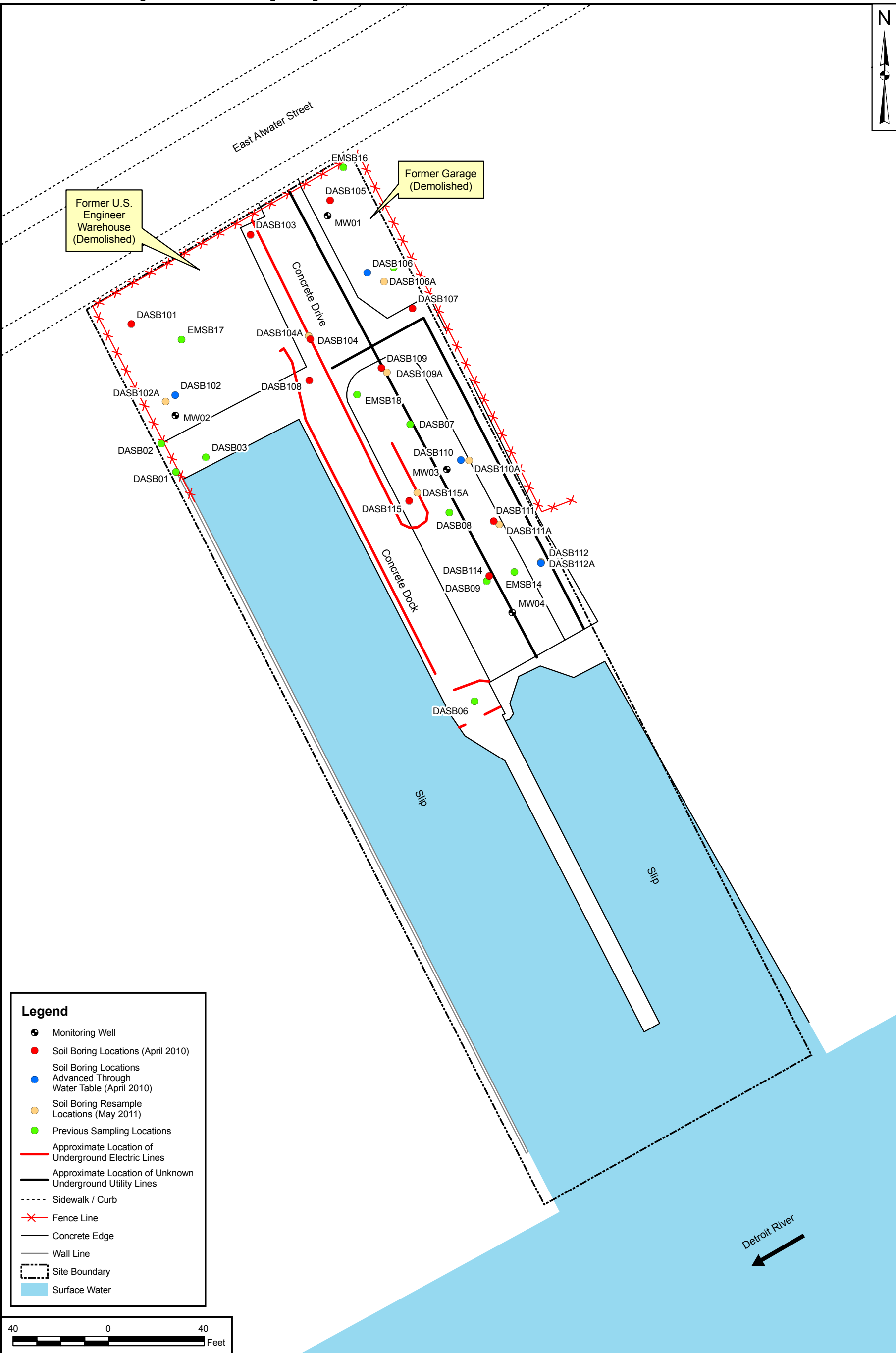
Table 1c. Potential Action-Specific Applicable or Relevant and Appropriate Requirements and To Be Considered Requirements, United States Coast Guard Atwater Facility, Detroit, Michigan

Action	Authority	Act or Statute	Regulation, Administrative Code, or Guidance Document	Status	Synopsis
Excavation of contaminated soil and monitoring or remediation related to impacts to groundwater.	Federal Advisories and Guidance.	None.	None.	NA.	NA.
	State Advisories and Guidance.	NA.	MDEQ Water Bureau Soil Erosion and Sedimentation (SES) Control Program, Soil Erosion and Sedimentation Training Manual SES Training Manual	To Be Considered.	This document includes non-promulgated guidance material prepared to assist in the design and construction of erosion and sedimentation control measures.
		NA.	MDEQ Remediation and Redevelopment Division (RRD) Operational Memorandum Number 2 (Part 201 Sampling and Analysis Guidance) MDEQ RRD Op Memo 2	To Be Considered.	This document is a non-promulgated memorandum prepared by the MDEQ to provide guidance on target detection limits and designated analytical methods; soil leaching methods; sample preservation, sampling, and handling and holding times; and the collection of samples for comparison to generic criteria.
			MDEQ RRD Operational Memorandum Number 4 (Site Characterization and Remediation Verification) MDEQ RRD Op Memo 4	To Be Considered.	This document is a non-promulgated memorandum prepared by the MDEQ to provide direction for generating data for facility characterization (nature, extent, and impact of a release or threat of a release) and monitoring to support remedial decisions and assessing exposure pathways for compliance with cleanup criteria. The sampling strategies identified in this document represent acceptable approaches and ranges of appropriate assumptions that are intended to support consistent exercise of professional judgment in a manner that produces satisfactory outcomes. Alternative approaches may be used if the person proposing the alternative demonstrates that the approach meets all requirements of the statute and rules.

Notes:
NA Not Applicable.

Table 2. Project Schedule for Removal Action, U.S. Coast Guard Atwater Facility, Detroit, Michigan.

Activities	Organization	Anticipated Date(s) of Initiation	Anticipated Date of Completion
QAPP / QAPPA / FSP Preparation	USCG/Tt	September 28, 2009	April 1, 2011
USEPA Review of Documents	USCG/Tt/USEPA Region 5	December 9, 2009	May 4, 2011
Site Inspection Report	USCG/Tt	May 29, 2011	October 16, 2012
EE/CA Report	USCG/Tt	August 30, 2011	November 28, 2012
Removal Action Work Plan	USCG/Tt	October 12, 2011	November 28, 2012
USEPA Review of Documents	USCG/Tt/USEPA Region 5	October 19, 2012	January 11, 2013
Public Participation Period	USCG/Tt	January 12, 2013	February 20, 2013
Site Preparation Activities	USCG/Tt	April 8, 2013	April 23, 2013
Implementation	USCG/Tt	April 24, 2013	May 21, 2013
Removal Action Completion Report	USCG/Tt	May 22, 2013	August 14, 2013
Monitoring Well Installation	USCG/Tt	May 22, 2013	May 29, 2013
Groundwater Sampling Event 1	USCG/Tt	June 13, 2013	June 13, 2013
Laboratory Analysis and Groundwater Sampling Report	USCG/Tt	June 14, 2013	August 1, 2013
Groundwater Sampling Event 2	USCG/Tt	September 11, 2013	September 11, 2013
Laboratory Analysis and Groundwater Sampling Report	USCG/Tt	September 12, 2013	October 30, 2013
Groundwater Sampling Event 3	USCG/Tt	December 10, 2013	December 10, 2013
Laboratory Analysis and Groundwater Sampling Report	USCG/Tt	December 11, 2013	January 28, 2014
Groundwater Sampling Event 4	USCG/Tt	March 11, 2014	March 11, 2014
Laboratory Analysis and Groundwater Sampling Report	USCG/Tt	March 12, 2014	April 29, 2014

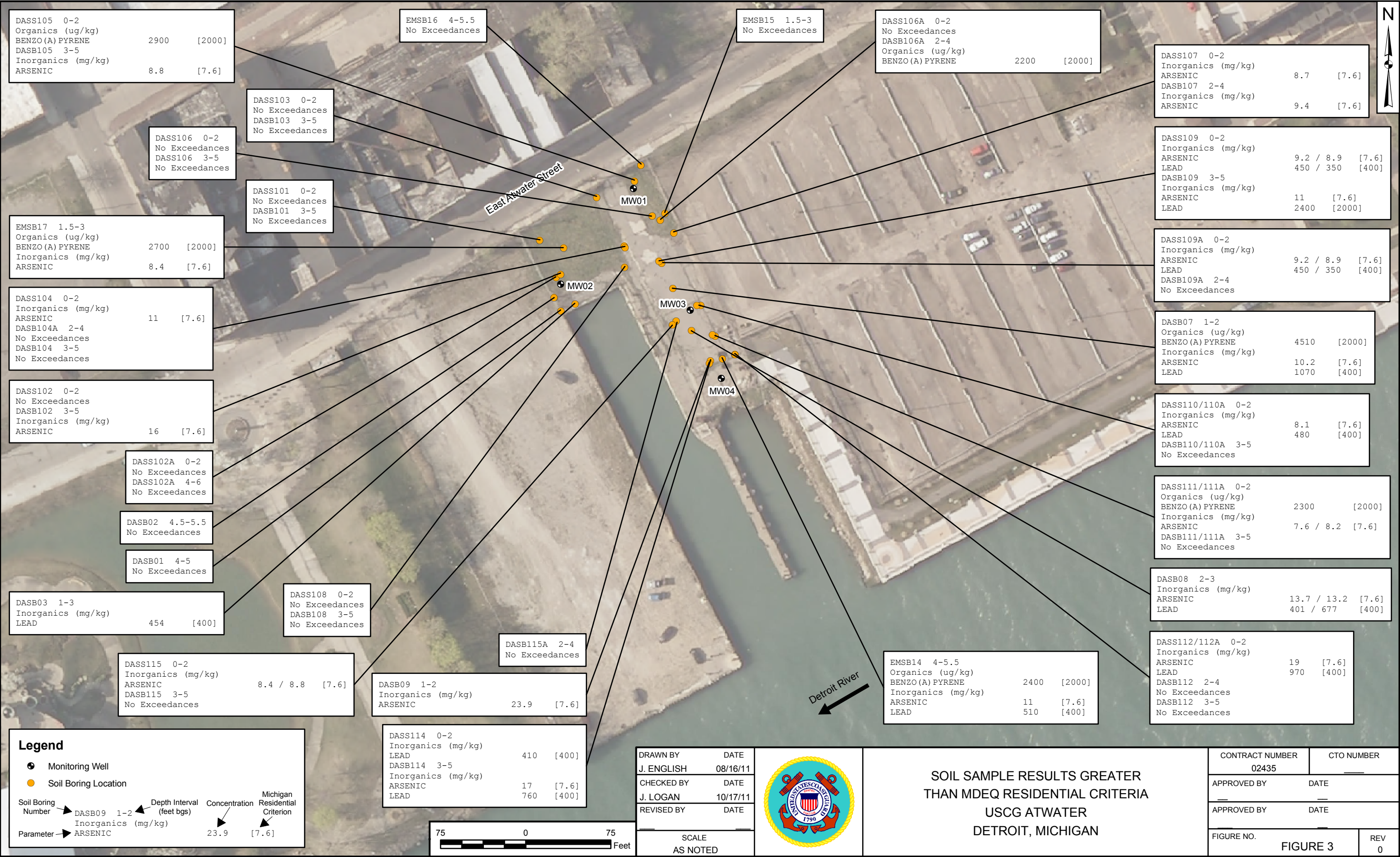


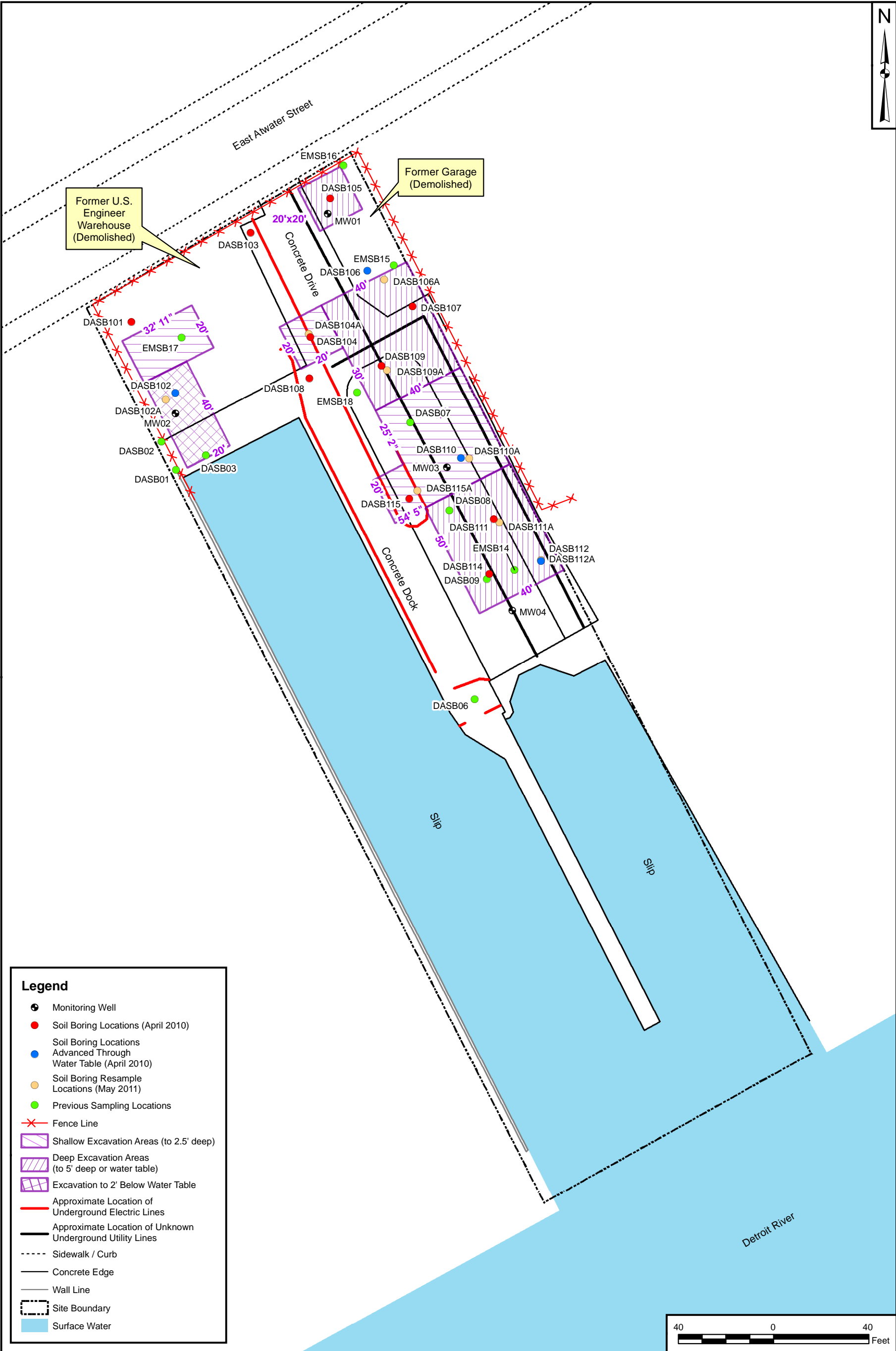
DRAWN BY	DATE
J. ENGLISH	09/23/11
CHECKED BY	DATE
S. VASKO	10/17/11
REVISED BY	DATE
SCALE	
AS NOTED	



SITE PLAN AND UTILITIES
ATWATER FACILITY
DETROIT, MICHIGAN

CONTRACT NUMBER	CTO NUMBER
02435	
APPROVED BY	DATE
APPROVED BY	DATE
FIGURE NO.	REV
FIGURE 2	0



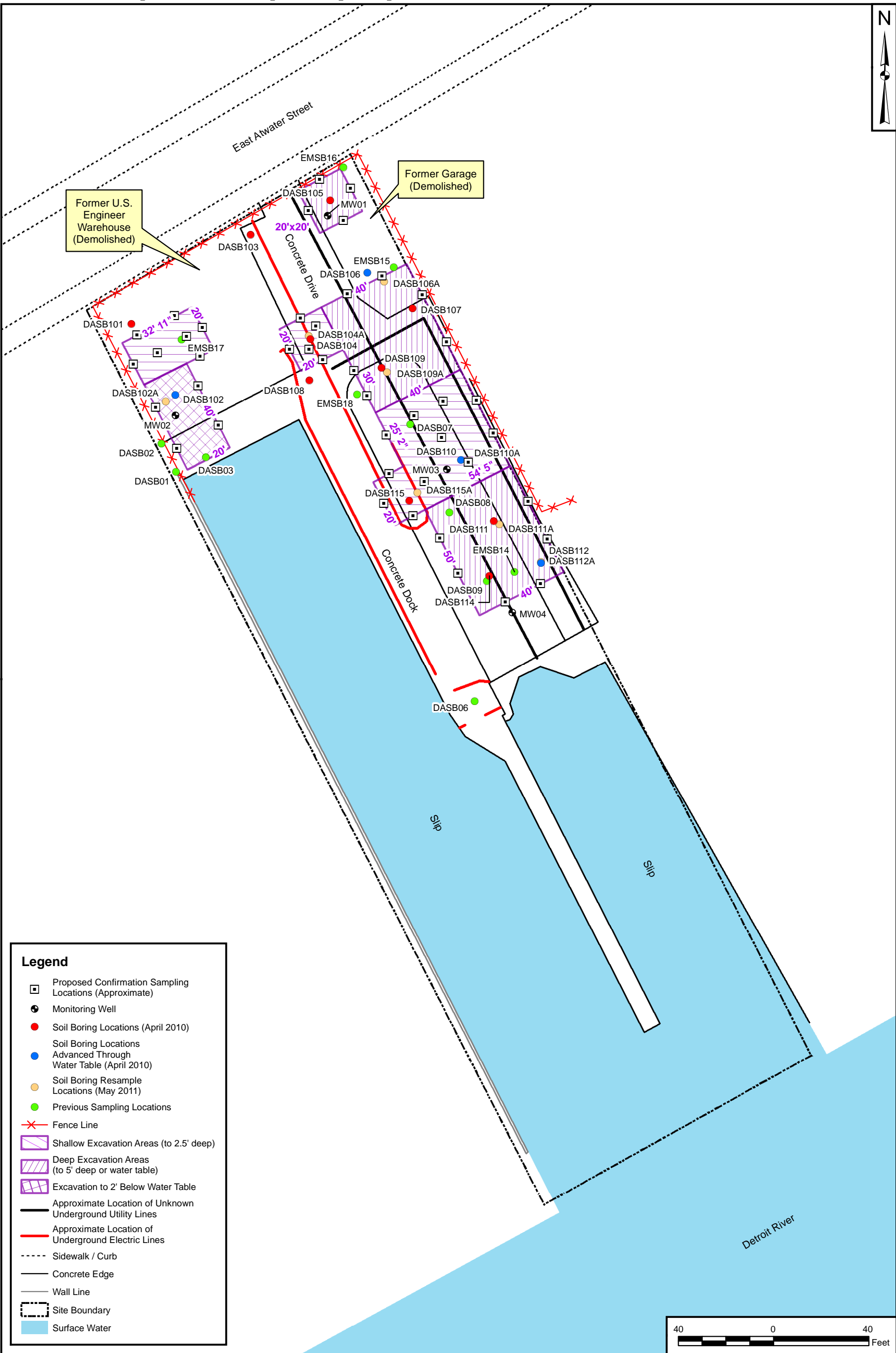


DRAWN BY	DATE
J. ENGLISH	09/23/11
CHECKED BY	DATE
S. VASKO	10/17/11
REVISD BY	DATE
SCALE	AS NOTED



SITE PLAN AND PROPOSED
EXTENT OF EXCAVATIONS
ATWATER FACILITY
DETROIT, MICHIGAN

CONTRACT NUMBER	CTO NUMBER
02435	
APPROVED BY	DATE
APPROVED BY	DATE
FIGURE NO.	REV
FIGURE 4	0



DRAWN BY	DATE
J. ENGLISH	11/14/12
CHECKED BY	DATE
S. VASKO	11/19/12
REVISED BY	DATE
SCALE AS NOTED	



PROPOSED CONFIRMATION
SAMPLING LOCATIONS
ATWATER FACILITY
DETROIT, MICHIGAN

CONTRACT NUMBER 02435	CTO NUMBER 02
APPROVED BY —	DATE —
APPROVED BY —	DATE —
FIGURE NO. FIGURE 6	REV 0

Appendix A

Correspondence



JENNIFER GRANHOLM
GOVERNOR

STATE OF MICHIGAN
DEPARTMENT OF HISTORY, ARTS AND LIBRARIES
LANSING

DR. WILLIAM ANDERSON
DIRECTOR

January 23, 2004

LAURETTE TULLY
U S COAST GUARD
1240 EAST NINTH STREET ROOM 2179
CLEVELAND OH 44199-2060

RE: ER-99-360 Demolition of U. S. Coast Guard Buildings at 2660 and 2670 Atwater, Detroit,
Wayne County (USCG)

Dear Ms. Tully:

Under the authority of Section 106 of the National Historic Preservation Act of 1966, as amended, we have reviewed the above-cited undertaking at the location noted above. Based on the information provided for our review, it is the opinion of the State Historic Preservation Officer (SHPO) that no historic properties are affected within the area of potential effects of this undertaking.

The views of the public are essential to informed decision making in the Section 106 process. Federal Agency Officials or their delegated authorities must plan to involve the public in a manner that reflects the nature and complexity of the undertaking, its effects on historic properties and other provisions per 36 CFR § 800.2(d). We remind you that Federal Agency Officials or their delegated authorities are required to consult with the appropriate Indian tribe and/or Tribal Historic Preservation Officer (THPO) when the undertaking may occur on or affect any historic properties on tribal lands. In all cases, whether the project occurs on tribal lands or not, Federal Agency Officials or their delegated authorities are also required to make a reasonable and good faith effort to identify any Indian tribes or Native Hawaiian organizations that might attach religious and cultural significance to historic properties in the area of potential effects and invite them to be consulting parties per 36 CFR § 800.2(c-f).

This letter evidences the USCG's compliance with 36 CFR § 800.4 "Identification of historic properties", and the fulfillment of the USCG's responsibility to notify the SHPO, as a consulting party in the Section 106 process, under 36 CFR § 800.4(d)(1) "No historic properties affected".

The State Historic Preservation Office is not the office of record for this undertaking. You are therefore asked to maintain a copy of this letter with your environmental review record for this undertaking. If the scope of work changes in any way, or if artifacts or bones are discovered, please notify this office immediately.

If you have any questions, please contact Brian G. Grennell, Environmental Review Specialist, at (517) 335-2721 or by email at ER@michigan.gov. **Please reference our project number in all communication with this office regarding this undertaking.** Thank you for this opportunity to review and comment, and for your cooperation.

Sincerely,


Martha MacFarlane Facs
Environmental Review Coordinator

for Brian D. Conway
State Historic Preservation Officer

MMF:REM:bgg

Appendix B

Standard Operating Procedures



HM
ENVIRONMENTAL
SERVICES Inc.

42826 N. Walnut
Mt. Clemens, MI 48043
Phone (586) 469-0041
Fax (586) 469-1014

Tetra Tech USCG Atwater Street Soil Remediation
Detroit, Michigan

Prior to mobilization to the site, HM Environmental will secure disposal approval for the impacted soils, contact MISSDIG to mark known utilities. HM Environmental Services, inc. will create a site specific HASP, to be followed while on-site.

Upon arrival on the site, a pre-construction meeting will be held with Tetra Tech to discuss site safety procedures and specific tasks. While on-site a morning tailgate safety meeting will be held prior to beginning any activities.

Once the pre-construction meeting is complete and the extent of excavation is determine in the field (with Tetra Tech), safety fence & barricades will be placed to secure the work area. The debris will be loaded and disposed of first, along with the steel tank. E&S controls will be installed prior to the start of excavation. The concrete surface above the area to be excavated will be broken and the surface removed. The excavation will be done with a trackhoe excavator and the soils loaded into dump trailers.

HM Environmental will attempt to save the curb and sidewalk at the entrance to the site, however the curb and sidewalk may have to be replaced.

The excavations will be sloped and all soils excavated for sloping will be shipped off-site as impacted.

No groundwater or surface water is to be encountered during the most of the excavation process. The excavation in the vicinity of MW02 will be extended approximately 2 feet below the water table. The saturated zone will be backfilled with 1x3 stone and covered with a geotextile prior to completing the backfilling of the excavation.

Once each excavation is complete we will backfill and compact the excavation. Resurfacing will be seed and mulch.

Dust will be controlled by water sprays. Water will be supplied by truck or a hydrant, if available.

Soils will be disposed of at Veolia Arbor Hills Landfill in Northville, Michigan.



STANDARD OPERATING PROCEDURES

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Applicability	Tetra Tech NUS, Inc.		
Prepared	Earth Sciences Department		
Approved	Tom Johnston <i>TE Johnston</i>		

Subject
SOIL SAMPLING

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1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the procedures to be used to collect surface, near-surface, and subsurface soil samples. Additionally, it describes the methods for sampling of test pits and trenches to determine subsurface soil and rock conditions and for recovery of small-volume or bulk samples from pits.

2.0 SCOPE

This document applies to the collection of surface, near-surface, and subsurface soil samples exposed through hand digging, hand augering, drilling, or machine excavating at hazardous substance sites for laboratory testing, onsite visual examination, and onsite testing.

3.0 GLOSSARY

Composite Sample - A composite sample is a combination of more than one grab sample from various locations and/or depths and times that is homogenized and treated as one sample. This type of sample is usually collected when determination of an average waste concentration for a specific area is required. Composite samples shall not be collected for volatile organics analysis.

Confined Space - As stipulated in 29 Code of Federal Regulations (CFR) 1910.146, a confined space means a space that: (1) is large enough and so configured that an employee can bodily enter and perform assigned work; (2) has limited or restricted means for entry or exit (e.g., tanks, vessels, silos, storage bins, hoppers, vaults, pits, and excavations); and (3) is not designed for continuous employee occupancy. TtNUS considers all confined space as permit-required confined spaces.

Grab Sample - One sample collected at one location and at one specific time.

Hand Auger - A sampling device used to extract soil from the ground.

Representativeness – A qualitative description of the degree to which an individual sample accurately reflects population characteristics or parameter variations at a sampling point. It is therefore an important characteristic not only of assessment and quantification of environmental threats posed by the site, but also for providing information for engineering design and construction. Proper sample location selection and proper sample collection methods are important to ensure that a truly representative sample has been collected.

Sample for Non-Volatile Analyses - Includes all chemical parameters other than volatile organics (e.g., semivolatiles, pesticides/PCBs, metals, etc.) and those engineering parameters that do not require undisturbed soil for their analysis.

Split-Barrel Sampler - A steel tube, split in half lengthwise, with the halves held together by threaded collars at either end of the tube. Also called a split-spoon sampler, this device can be driven into resistant materials using a drive weight mounted in the drilling string. A standard split-barrel sampler is typically available in two common lengths, providing either 20-inch or 26-inch longitudinal clearance for obtaining 18-inch or 24-inch-long samples, respectively. These split-barrel samplers commonly range in size from 2 to 3.5 inches OD. The larger sizes are commonly used when a larger volume of sample material is required (see Attachment B).

Test Pit and Trench - Open, shallow excavations, typically rectangular (if a test pit) or longitudinal (if a trench), excavated to determine shallow subsurface conditions for engineering, geological, and soil chemistry exploration and/or sampling purposes. These pits are excavated manually or by machine (e.g., backhoe, clamshell, trencher, excavator, or bulldozer).

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Thin-Walled Tube Sampler - A thin-walled metal tube (also called a Shelby tube) used to recover relatively undisturbed soil samples. These tubes are available in various sizes, ranging from 2 to 5 inches outside diameter (OD) and from 18 to 54 inches in length.

4.0 RESPONSIBILITIES AND PERSONNEL QUALIFICATIONS

Project Manager - The Project Manager is responsible for determining the sampling objectives, selecting proposed sampling locations, and selecting field procedures used in the collection of soil samples. Additionally, in consultation with other project personnel (geologist, hydrogeologist, etc.), the Project Manager establishes the need for test pits or trenches and determines their approximate locations and dimensions.

Site Safety Officer (SSO) - The SSO (or a qualified designee) is responsible for providing the technical support necessary to implement the project Health and Safety Plan. This will include (but not be limited to) performing air quality monitoring during sampling, boring, and excavation activities and to ensure that workers and offsite (downwind) individuals are not exposed to hazardous levels of airborne contaminants. The SSO/designee may also be required to advise the FOL on other safety-related matters regarding boring, excavation, and sampling, such as mitigative measures to address potential hazards from unstable trench walls, puncturing of drums or other hazardous objects, etc.

Field Operations Leader (FOL) - This individual is primarily responsible for the execution of the planning document containing the Sampling and Analysis Plan (SAP). This is accomplished through management of a field sampling team for the proper acquisition of samples. He or she is responsible for the supervision of onsite analyses; ensuring proper instrument calibration, care, and maintenance; sample collection and handling; the completion and accuracy of all field documentation; and making sure that custody of all samples obtained is maintained according to proper procedures. When appropriate and as directed by the FOL, such responsibilities may be performed by other qualified personnel (e.g., field technicians) where credentials and time permit. The FOL is responsible for finalizing the locations for collection of surface, near-surface, and subsurface (hand and machine borings, test pits/trenches) soil samples. He/she is ultimately responsible for the sampling and backfilling of boreholes, test pits, and trenches and for adherence to Occupational Safety and Health Administration (OSHA) regulations during these operations through self acquisition or through the management of a field team of samplers.

Project Geologist/Sampler - The project geologist/sampler is responsible for the proper acquisition of samples in accordance with this SOP and/or other project-specific documents. In addition, this individual is responsible for the completion of all required paperwork (e.g., sample log sheets, field notebook, boring logs, test pit logs, container labels, custody seals, and chain-of-custody forms) associated with the collection of those samples.

Competent Person - A Competent Person, as defined in 29 CFR 1929.650 of Subpart P - Excavations, means one who is capable of identifying existing and predictable hazards in the surroundings, or working conditions that are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them.

General personnel qualifications for groundwater sample collection and onsite water quality testing include the following:

- Occupational Safety and Health Administration (OSHA) 40-hour and applicable refresher training.
- Capability of performing field work under the expected physical and environmental (i.e., weather) conditions.

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- Familiarity with appropriate procedures for sample documentation, handling, packaging, and shipping.

5.0 HEALTH AND SAFETY

Health and safety precautions are identified for individual sample collection procedures throughout this SOP. In addition to those precautions, the following general hazards may be incurred during sampling activities:

- Knee injuries from kneeling on hard or uneven surfaces
- Slips, trips, and falls
- Cuts and lacerations
- Traffic hazards associated with sampling in parking areas, along roadways and highways.

Methods of avoiding these hazards are provided below.

Knee injuries – If kneeling is required during soil sampling, this could result in knee injuries from stones/foreign objects and general damage due to stress on the joints. To minimize this hazard:

- Clear any foreign objects from the work area.
- Wear hard-sided knee pads.
- Stretch ligaments, tendons and muscles before, during and after. Take breaks as frequently as necessary.
- Report pre-existing conditions to the SSO if you feel this activity will aggravate an existing condition.

Slips, Trips, and Falls – These hazards exist while traversing varying terrains carrying equipment to sample locations. To minimize these hazards:

- Pre-survey sampling locations. Eliminate, barricade, or otherwise mark physical hazards leading to the locations.
- Carry small loads that do not restrict the field of vision.
- Travel the safest and clearest route (not necessarily the shortest).

Cuts and Lacerations - To prevent cuts and lacerations associated with soil sampling, the following provisions are required:

- Always cut away from yourself and others when cutting tubing or rope. This will prevent injury to yourself and others if the knife slips.
- Do not place items to be cut in your hand or on your knee.
- Change blades as necessary to maintain a sharp cutting edge. Many accidents result from struggling with dull cutting attachments.

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- Whenever practical, wear cut-resistant gloves (e.g., leather or heavy cotton work gloves) at least on the hand not using the knife.
- Keep cutting surfaces clean and smooth.
- Secure items to be cut – do not hold them against the opposing hand, a leg, or other body part.
- When transporting glassware, keep it in a hard-sided container such as a cooler so that if there is a fall, you will be less likely to get cut by broken glass.
- DO NOT throw broken sample jars or glass ampoules into garbage bags. Place broken glass and glass ampoules in hard-sided containers such as a cardboard box or directly into a dumpster. DO NOT reach into garbage bags to retrieve any item accidentally thrown away. Empty the contents onto a flat surface to avoid punctures and lacerations from reaching where you cannot see.

Vehicular and Foot Traffic Hazards – When sampling along the roadway or near traffic patterns, follow the following precautions:

- Motorists may be distracted by onsite activities – ASSUME THEY DO NOT SEE YOU OR MEMBERS OF YOUR FIELD CREW.
- DO NOT place obstructions (such as vehicles) along the sides of the road that may cause site personnel to move into the flow of traffic to avoid your activities or equipment or that will create a blind spot.
- **Provide a required free space of travel.** Maintain at least 6 feet of space between you and moving traffic. Where this is not possible, use flaggers and/or signs to warn oncoming traffic of activities near or within the travel lanes.
- Face Traffic. Whenever feasible, if you must move within the 6 feet of the required free space or into traffic, attempt to face moving traffic at all times. Always leave yourself an escape route.
- Wear high-visibility vests to increase visual recognition by motorists.
- Do not rely on the vehicle operator's visibility, judgment, or ability. Make eye contact with the driver. Carefully and deliberately use hand signals so they will not startle or confuse motorists or be mistaken for a flagger's direction before moving into traffic.
- Your movements may startle a motorist and cause an accident, so move deliberately. Do not make sudden movements that might confuse a motorist.

6.0 PROCEDURES

The following procedures address surface and subsurface sampling.

CAUTION

Each situation must be evaluated individually to determine the applicability and necessity for obtaining a utility clearance ticket/dig permit. Common sense dictates, prior to digging or boring with power equipment, no matter what the depth, or digging by hand in a manner that could damage unprotected underground utilities, that a dig permit is required. See SOP HS-1.0, Utility Locating and Excavation Clearance, for additional clarification. If you do not know or are unsure as to whether a ticket is necessary – **Get the Ticket.**

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6.1 Overview

Soil sampling is an important adjunct to groundwater monitoring. Sampling of the soil horizons above the groundwater table can detect contaminants before they migrate to the water table, and can establish the amount of contamination absorbed or adsorbed on aquifer solids that have the potential of contributing to groundwater contamination.

Soil types can vary considerably on a hazardous waste site. These variations, along with vegetation, can affect the rate of contaminant migration through the soil. It is important, therefore, that a detailed record be maintained during sampling operations, particularly noting sampling locations, depths, and such characteristics as grain size, color, and odor. Subsurface conditions are often stable on a daily basis and may demonstrate only slight seasonal variation especially with respect to temperature, available oxygen and light penetration. Changes in any of these conditions can radically alter the rate of chemical reactions or the associated microbiological community, thus further altering specific site conditions. Certain vegetation species can create degradation products that can alter contaminant concentrations in soil. This is why vegetation types and extent of degradation of this foliage must be recorded. To prevent degradation, samples must be kept at their at-depth temperature or lower, protected from direct light, sealed tightly in approved glass containers, and be analyzed as soon as possible after collection. In addition, to the extent possible, vegetation should be removed from the sample.

The physical properties of the soil, its grain size, cohesiveness, associated moisture, and such factors as depth to bedrock and water table, will limit the depth from which samples can be collected and the method required to collect them. It is the intent of this document to present the most commonly employed soil sampling methods used at hazardous waste sites.

6.2 Soil Sample Collection

6.2.1 Procedure for Preserving and Collecting Soil Samples for Volatile Organic Compound Analysis

Samples collected using traditional methods such as collection in a jar with no preservation have been known to yield non-representative samples due to loss of volatile organic compounds (VOCs). To prevent such losses, preservation of samples with methanol or sodium bisulfate may be used to minimize volatilization and biodegradation. This preservation may be performed either in the field or laboratory, depending on the sampling methodology employed. Because of the large number of sampling methods and associated equipment required, careful coordination between field and laboratory personnel is needed.

Soil samples to be preserved by the laboratory are currently being collected using Method SW-846, 5035. For samples preserved in the field, laboratories are currently performing low-level analyses (sodium bisulfate preservation) and high- to medium-level analyses (methanol preservation) depending on the needs of the end user.

The following procedures outline the necessary steps for collecting soil samples to be preserved at the laboratory, and for collecting soil samples to be preserved in the field with methanol or sodium bisulfate.

6.2.1.1 Soil Samples to be Preserved at the Laboratory

Soil samples collected for volatile organic analysis that are to be preserved at the laboratory shall be obtained using a hermetically sealed sample vial such as an EnCore™ sampler. Each sample shall be

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obtained using a reusable sampling handle (T-handle) that can be provided with the EnCore™ sampler when requested and purchased. Collect the sample in the following manner for each EnCore™ sampler:

1. Scene Safety - Evaluate the area where sampling will occur. Ensure that the area is safe from physical, chemical, and natural hazards. Clear or barricade those hazards that have been identified.
2. Wear the appropriate personal protective equipment (PPE). This will include, at a minimum, safety glasses and nitrile surgeon's gloves. If you must kneel on the ground or place equipment on the surface being sampled, cover the ground surface with plastic to minimize surface contamination of your equipment and clothing. Wear knee pads to protect your knees from kneeling on hard or uneven surfaces.
3. Load the Encore™ sampler into the T-handle with the plunger fully depressed.
4. Expose the area to be sampled using a hand trowel or similar device to remove surface debris.
5. Press the T-handle against the freshly exposed soil surface, forcing soil into the sampler. The plunger will be forced upward as the cavity fills with soil.
6. When the sampler is full, rotate the plunger and lock it into place. If the plunger does not lock, the sampler is not full. This method ensures there is no headspace. Soft soil may require several plunges or forcing soil against a hard surface such as a sample trowel to ensure that headspace is eliminated.
7. Use a paper towel to remove soil from the side of the sampler so a tight seal can be made between the sample cap and the rubber O-ring.
8. With soil slightly piled above the rim of the sampler, force the cap on until the catches hook the side of the sampler.
9. Remove any surface soil from the outside of the sampler and place in the foil bag provided with the sampler. Good work hygiene practices and diligent decontamination procedures prevents the spread of contamination even on the outside of the containers.
10. Label the bag with appropriate information in accordance with SOP SA-6.3.
11. Place the full sampler inside a lined cooler with ice and cool to $4^{\circ}\text{C} \pm 2^{\circ}\text{C}$. Make sure any required trip blanks and temperature blanks are also in the cooler. Secure custody of the cooler in accordance with SOP SA-6.3.
12. Typically, collect three Encore™ samplers at each location. Consult the SAP or laboratory to determine the required number of Encore™ samplers to be collected.
13. The T-handle shall be decontaminated before moving to the next interval or location using a soap and water wash and rinse, and where applicable, the selected solvent as defined in the project planning documents.

Using this type of sampling device eliminates the need for field preservation and the shipping restrictions associated with preservatives. A complete set of instructions is included with each Encore™ sampler.

After the Encore™ samples are collected, they should be placed on ice immediately and delivered to the laboratory within 48 hours (following the chain-of-custody and documentation procedures outlined in SOP SA-6.1). Samples must be preserved by the laboratory within 48 hours of sample collection.

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6.2.1.2 Soil Samples to be Preserved in the Field

Soil samples preserved in the field may be prepared for analyses using both the low-level (sodium bisulfate preservation) and high- to medium-level (methanol preservation) methods.

Safety Reminder

When using chemicals in the field to preserve samples, the FOL and/or SSO must ensure that Materials Safety Data Sheets (MSDSs) have been provided with the chemicals to be used. They also must ensure that these chemicals have been added to the Chemical Inventory List contained within Section 5.0, Hazard Communication, of your Health and Safety Guidance Manual (HSGM). Lastly, but most importantly, the FOL and/or SSO must review the hazards with personnel using these chemicals and ensure that provisions are available for recommended PPE and emergency measures (e.g., eyewash, etc.).

Methanol Preservation (High to Medium Level):

Bottles may be pre-spiked with methanol in the laboratory or prepared in the field. Soil samples to be preserved in the field with methanol shall utilize 40 to 60 mL glass vials with septum-lined lids. Each sample bottle shall be filled with 25 mL of demonstrated analyte-free purge-and-trap grade methanol. The preferred method for adding methanol to the sample bottle is by removing the lid and using a pipette or scaled syringe to add the methanol directly to the bottle.

CAUTION

NEVER attempt to pipette by mouth

In situations where personnel are required to spike the septum using a hypodermic needle, the following provisions for handling sharps must be in place:

- Training of personnel regarding methods for handling of sharps
- Hard-sided containers for the disposal of sharps
- Provisions for treatment in cases where persons have received a puncture wound

Soil shall be collected with the use of a decontaminated (or disposable), small-diameter coring device such as a disposable tube/plunger-type syringe with the tip cut off. The outside diameter of the coring device must be smaller than the inside diameter of the sample bottle neck.

A small electronic balance or manual scale will be necessary for measuring the volume of soil to be added to the methanol-preserved sample bottle. Calibration of the scale shall be performed prior to use and intermittently throughout the day according to the manufacturer's requirements.

The sample should be collected as follows:

1. Weigh the unused syringe and plunger to the nearest 0.01 gram.
2. Pull the plunger back and insert the syringe into the soil to be sampled.
3. Collect 8 to 12 grams of soil by pushing the syringe barrel into the soil.
4. Weigh the sample and adjust until obtaining the required amount of sample.

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5. Record the sample weight to the nearest 0.01 gram in the field logbook and/or on the sample log sheet.
6. Extrude the weighed soil sample into the methanol-preserved sample bottle taking care not to contact the sample container with the syringe.
7. If dirty, wipe soil particles from the threads of the bottle and cap. Cap the bottle tightly.
8. After capping the bottle, swirl the sample (do not shake) in the methanol and break up the soil such that all of the soil is covered with methanol.
9. Place the sample on ice immediately and prepare for shipment to the laboratory as described in SOP SA-6.1.

Sodium Bisulfate Preservation (Low Level):

CAUTION

Care should be taken when adding the soil to the sodium bisulfate solution. A chemical reaction of soil containing carbonates (limestone) may cause the sample to effervesce or the vial to possibly explode. To avoid this hazard or hazards of this type, a small sample aliquot should be subjected to the sample preservative. If it effervesces in an open air environment, utilize an alternative method such as Encore™ or 2-ounce jar.

Bottles may be prepared in the laboratory or in the field with sodium bisulfate solution. Samples to be preserved in the field using the sodium bisulfate method are to be prepared and collected as follows:

1. Add 1 gram of sodium bisulfate to 5 mL of laboratory-grade deionized water in a 40 to 60 mL glass vial with septum-lined lid.
2. Collect the soil sample and record the sample weight to the nearest 0.01 gram in the field logbook or on the sample log sheet as described for methanol preservation
3. Add the weighed sample to the sample vial.
4. Collect duplicate samples using the methanol preservation method on a one-for-one sample basis because it is necessary for the laboratory to perform both low-level and medium-level analyses.
5. Place the samples on ice immediately and prepare for shipment to the laboratory as described in SOP SA-6.1.

NOTE

If lower detection limits are necessary, an option to field preserving with sodium bisulfate may be to collect EnCore™ samplers at a given sample location. Consult the planning documents to determine whether this is required. If it is, collect samples in accordance with the Encore™ sampling procedure above and then send all samplers to the laboratory to perform the required preservation and analyses.

6.2.2 Procedure for Collecting Soil Samples for Non-Volatile Analyses

Samples collected for non-volatile analyses may be collected as either grab or composite samples as follows:

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1. With a stainless steel trowel or other approved tool, transfer a portion of soil to be sampled to a stainless steel bowl or disposable inert plastic tray.
2. Remove roots, vegetation, sticks, and stones larger than the size of a green pea.
3. Thoroughly mix the soil in the bowl or tray to obtain as uniform a texture and color as practicable. The soil type, moisture content, amount of vegetation, and other factors may affect the amount of time required to obtain a properly mixed sample. In some cases, it may be impossible to obtain a uniform sample appearance. Use the field logbook to describe any significant difficulties encountered in obtaining a uniform mixture.
4. Transfer the mixed soil to the appropriate sample containers and close the containers.
5. Label the sample containers in accordance with SOP SA-6.3.
6. Place the containers in a cooler of ice as soon after collection as possible.
7. Prepare the sample shipment and ship the samples in accordance with SOP SA-6.1.

NOTE

Cooling may not be required for some samples depending on the scheduled analyses. Consult the planning documents if in doubt regarding correct sample preservation conditions. When in doubt – Cool to 4° C.

NOTE

Head space is permitted in soil sample containers for non-volatile analyses to allow for sample expansion.

6.2.3 Procedure for Collecting Undisturbed Soil Samples

NOTE

Use of thin-walled undisturbed tube samplers is restricted by the consistency of the soil to be sampled. Often, very loose and/or wet samples cannot be retrieved by the samplers, and soil with a consistency in excess of very stiff cannot be penetrated by the sampler. Devices such as Dennison or Pitcher core samplers can be used to obtain undisturbed samples of stiff soil. Using these devices normally increases sampling costs, and therefore their use should be weighed against the need for acquiring an undisturbed sample. These devices are not discussed in this SOP because they are not commonly used.

When it is necessary to acquire undisturbed samples of soil for purposes of engineering parameter analysis (e.g., permeability), a thin-walled, seamless tube sampler (Shelby tube) shall be employed using the following collection procedure:

1. In preparation for sampling utilizing a drill rig, field personnel must complete the following activities:
 - Ensure that all subsurface drilling activities are preceded by a utility clearance for the area to be investigated. This includes activities described in SOP HS-1.0, Utility Location and Excavation Clearance, as well as any location-specific procedures that may apply.

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REMEMBER

If you are digging near a marked utility (within the diameter of an underground utility that has been marked plus 18 inches), you must first locate the utility through vacuum extraction or hand digging to ensure that your activities will not damage the utility.

- Complete an Equipment Inspection Checklist for the drill rig or direct-push technology (DPT) rig. This checklist will be provided in the HASP.
 - Review the Safe Work Permit prior to conducting the activity.
 - Review the activity to be conducted.
2. Remove all surface debris (e.g., vegetation, roots, twigs, etc.) from the specific sampling location and drill and/or clean out the borehole to the desired sampling depth. Be careful to minimize potential disturbance of the material to be sampled. In saturated material, withdraw the drill bit slowly to prevent loosening of the soil around the borehole and to maintain the water level in the hole at or above groundwater level.

CAUTION

The use of bottom-discharge bits or jetting through an open-tube sampler to clean out the borehole shall not be allowed. Only the use of side-discharge bits is permitted.

3. Determine whether a stationary piston-type sampler is required to limit sample disturbance and aid in retaining the sample. Either the hydraulically operated or control rod activated-type of stationary piston sampler may be used.
4. Prior to inserting the tube sampler into the borehole, check to ensure that the sampler head contains a check valve. The check valve is necessary to keep water in the rods from pushing the sample out the tube sampler during sample withdrawal. In addition, the check valve maintains a positive suction within the tube to help retain the sample.
5. A stainless steel tube sampler is typically used to minimize chemical reaction between the sample and the sampling tube.
6. With the sampling tube resting on the bottom of the hole and the water level in the boring at groundwater level or above, push the tube into the soil with a continuous and rapid motion, without impacting or twisting. If the soil is too hard to penetrate by pushing alone, careful hammering may be used by minimizing drop distance (tapping) of the hammer. Before pulling the tube, turn it at least one revolution to shear the sample off at the bottom. In no case shall the tube be pushed farther than the length provided for the soil sample. Allow about 3 inches in the tube for cuttings and sludge.
7. Upon removal of the sampling tube from the hole, measure the length of sample in the tube and also the length penetrated.
8. Remove disturbed material in the upper end of the tube and measure the length of sample again.
9. After removing at least 1 inch of soil from the lower end, place enough packing material (clean inert material such as paper or cloth) tightly in each end of the Shelby tube and then pour melted wax into each end to make at least a ½-inch wax plug and then add more packing material to fill the voids at both ends.

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10. Place plastic caps on the ends, tape the caps in place, and dip the ends in wax to prevent loss of soil.
11. Affix label(s) to the tube as required and record sample number, depth, penetration, and recovery length on the label.
12. Mark the "up" direction on the side and upper end of the tube with indelible ink.
13. Complete a chain-of-custody form (see SOP SA-6.3) and other required forms (including Attachment A of this SOP).
14. Ship samples protected with suitable resilient packing material to reduce shock, vibration, and disturbance.

CAUTION

To preserve sample integrity do not allow tubes to freeze, and store the samples vertically with the same orientation they had in the ground, (i.e., top of sample is up) in a cool place out of the sun at all times.

CAUTION

A primary concern in the preparation of the wax plugs is the potential for the heat source and melted wax to cause a fire and/or burns. Follow the directions below to prevent injury or fire.

Electrical Heating

Using hot plates to melt the wax is acceptable. In an outdoor setting, make sure a Ground Fault Circuit Interrupter (GFCI) is employed within the electrical circuit. If a portable generator is used, ensure that the generator is an adequate distance from the sampling operation (at least 50 feet). Ensure that the extension cord is rated for the intended load and for outdoor use and is free from recognizable damage. Ensure flammable preservatives are not employed or stored near the hot plate. Although a Hot Work Permit is not required, scene safety evaluation by site personnel of the above elements is. As always, if a fire potential exists, the provisions for extinguishing must be immediately accessible as well as any provisions for first aid measures.

Open Flame

If an open flame is used, the following provisions are necessary:

- Complete a Hot Work Permit and any local permit required for elevated temperature applications. The Hot Work Permit, provided in your HASP, will aid the FOL and/or the SSO in ensuring that fire protection provisions (extinguishers, fire watches, etc.) are in place as well as ensuring that local requirements have been addressed.
- Ensure that water is available to address any wax splashes or contact. If possible, immerse the contacted area. Where this is not possible, run water over the area and apply cold compresses. The need for medical attention or first aid shall be determined on site under the direction of the SSO.

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6.3 Surface Soil Sampling

The simplest, most direct method of collecting surface soil samples for subsequent analysis is by use of a stainless steel shovel, hand auger, soil corer, or stainless steel or disposable plastic trowel.

NOTE

Multiple depth intervals are used to describe surface soil. Sometimes surface soil is defined as soil from 0 to 2 inches below ground surface (bgs), and sometimes it is defined as soil from other depths such as 0 to 2 feet bgs. Ensure that the definition of surface soil depth is clear before collecting surface soil samples.

For the purposes of instruction, the terms "surface soil" and "near-surface soil" are used in this SOP as follows:

- Surface soil - 0 to 6 inches bgs
- Near-surface soil - 6 to 18 inches bgs

If these intervals are defined differently in the planning documents, substitute the appropriate depth ranges.

In general, the following equipment is necessary for obtaining surface soil samples:

- Stainless steel or pre-cleaned disposable trowel.
- Stainless steel hand auger, soil corer, or shovel.
- Real-time air monitoring instrument (e.g., PID, FID) as directed in project planning document.
- Required PPE.
 - Nitrile surgeon's or latex gloves may be used, layered as necessary.
 - Safety glasses
 - Other – Items identified on the Safe Work Permit may be required based on location-specific requirements such as hearing protection, steel-toed work boots, and a hard hat when working near a drill rig. These provisions will be listed in the HASP or directed by the FOL and/or SSO.

Safety Reminder

The use of latex products may elicit an allergic reaction in some people. Should this occur, remove the latex gloves, treat for an allergic reaction, and seek medical attention as necessary.

- Required paperwork (see SOP SA-6.3 and Attachment A of this SOP)
- Required decontamination equipment
- Required sample container(s)
- Wooden stakes or pin flags

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- Sealable polyethylene bags (e.g., Ziploc® baggies)
- Heavy duty cooler
- Ice
- Chain-of-custody records and custody seals

When acquiring surface soil samples, use the following procedure:

1. Place padding or use knee pads when kneeling near the sample location. If necessary, place plastic sheeting to provide a clean surface for sample equipment to avoid possible cross- contamination.
2. Carefully remove vegetation, roots, twigs, litter, etc. to expose an adequate soil surface area to accommodate sample volume requirements.
3. Using a precleaned syringe or EnCore™ samplers, follow the procedure in Section 6.2.1 for collecting surface soil samples for volatile analysis. Surface soil samples for volatile organic analysis should be collected deeper than 6 inches bgs because shallower material has usually lost most of the volatiles through evaporation. Ensure that the appropriate surface soil depth is being analyzed in accordance with the planning document.
4. Using decontaminated sampling tools, thoroughly mix in place a sufficient amount of soil to fill the remaining sample containers. See Section 6.5 of this procedure for hand auger instruction, as needed.
5. Transfer the sample into those containers utilizing a stainless steel trowel.
6. Cap and securely tighten all sample containers.
7. Affix a sample label to each container. Be sure to fill out each label carefully and clearly, addressing all the categories described in SOP SA-6.3.
8. Proceed with the handling and processing of each sample container as described in SOP SA-6.2.
9. Site restoration – Whenever removing sample materials, always restore the surface. It is our intent to leave the area better than we found it. Do NOT create trip hazards in areas when pedestrian traffic may exist.

6.4 Near-Surface Soil Sampling

Collection of samples from near the surface (depth of 6 to 18 inches) can be accomplished with tools such as shovels, hand auger, soil corers, and stainless steel or pre-cleaned disposable trowels and the equipment listed under Section 6.5 of this procedure.

To obtain near-surface soil samples, the following protocol shall be used:

1. With a clean shovel, make a series of vertical cuts in the soil to the depth required to form a square approximately 1 foot by 1 foot.
2. Lever out the formed plug and scrape the bottom of the freshly dug hole with a decontaminated stainless steel or pre-cleaned disposable trowel to remove any loose soil.

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3. Follow steps 1 through 9 of Section 6.3.

6.5 Subsurface Soil Sampling With a Hand Auger

A hand augering system generally consists of a variety of stainless steel bucket bits (approximately 6.5 inches long and 2, 2.75, 3.25, and 4 inches in diameter), series of extension rods (available in 2-, 3-, 4- and 5-inch lengths), and a T-handle connected to extension rods and to the auger bucket. A larger-diameter bucket bit is commonly used to bore a hole to the desired sampling depth and then it is withdrawn. The larger-diameter bit is then replaced with a smaller-diameter bit, lowered down the hole, and slowly turned into the soil to the completion depth (approximately 6 inches). The apparatus is then withdrawn and the soil sample collected.

The hand auger can be used in a wide variety of soil conditions. It can be used to sample soil either from the surface, or to depths in excess of 12 feet. However, the presence of subsurface rocks and landfill material and collapse of the borehole normally limit sampling depth.

To accomplish soil sampling using a hand augering system, the following equipment is required:

- Complete hand auger assembly (variety of bucket bit sizes)
- Stainless steel mixing bowls
- The equipment listed in Section 6.3
- Miscellaneous hand tools as required to assemble and disassemble the hand auger units

CAUTION

Potential hazards associated with hand augering include:

- Muscle strain and sprain due to over twisting and/or over compromising yourself.
- Equipment failure due to excessive stress on the T-handle or rods through twisting. Failure of any of these components will result in a sudden release and potential injury due to that failure.

As in all situations, any intrusive activities that could damage underground utilities shall be preceded by a Dig/Excavation permit/ticket. Call the Utility Locating service in the area or your Project Health and Safety Officer for more information. When in doubt – **Get the Ticket!**

To obtain soil samples using a hand auger, use the following procedure:

1. Wearing designated PPE, attach a properly decontaminated bucket bit to a clean extension rod and attach the T-handle to the extension rod.
2. Clear the area to be sampled of any surface debris (vegetation, twigs, rocks, litter, etc.).
3. Twist the bucket into the ground while pushing vertically downward on the auger. The cutting shoes fill the bucket as it is advanced into the ground.
4. As the auger bucket fills with soil, periodically remove any unneeded soil.

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5. Add rod extensions as necessary to extend the reach of the auger. Also, note (in a field notebook, boring log, and/or on a standardized data sheet) any changes in the color, texture or odor of the soil as a function of depth. The project-specific planning document (SAP, HASP, etc.) describe requirements for scanning the soil with a real-time air monitoring instrument (e.g., PID, FID, etc.) and recording the measurements.
6. After reaching the desired depth (e.g., the top of the interval to be sampled), slowly and carefully withdraw the apparatus from the borehole to prevent or minimize movement of soil from shallower intervals to the bottom of the hole.
7. Remove the soiled bucket bit from the rod extension and replace it with another properly decontaminated bucket bit. The bucket bit used for sampling is to be smaller in diameter than the bucket bit employed to initiate the borehole.
8. Carefully lower the apparatus down the borehole. Care must be taken to avoid scraping the borehole sides.
9. Slowly turn the apparatus until the bucket bit is advanced approximately 6 inches.
10. Discard the top of the core (approximately 1 inch), which represents any loose material collected by the bucket bit before penetrating the sample material.
11. Using a precleaned syringe or EnCore™ samplers, follow the procedure in Section 6.2.1 for collecting a soil sample for volatile compound analysis directly from the bucket bit.
12. Utilizing a properly decontaminated stainless steel trowel or dedicated disposable trowel, remove the remaining sample material from the bucket bit and place into a properly decontaminated stainless steel mixing bowl.
13. Homogenize the sample material as thoroughly as practicable then fill the remaining sample containers. Refer to Section 6.2.2.
14. Follow steps 4 through 7 listed in Section 6.3.

6.5.1 Sampling Using Stainless Steel Soil Corers

A soil corer is a stainless steel tube equipped with a cutting shoe and sample window in the side. The soil corer is advanced into the soil by applying downward pressure (body weight). The soil is unloaded by then forcing a ram towards the cutting shoe, which results in the discharge of the soil core through a window in the sleeve.

Use, application, and sample protocol is the same as for hand augering provided above, but without necessarily rotating the corer while advancing it.

SAFETY REMINDER

Hand augering and soil corer sampling can be physically demanding based on the type of geology and subsurface encumbrances encountered. Soil coring has some added hazards such the corer collapsing under your weight. To reduce the potential for muscle strain and damage, the following measures will be incorporated:

- Stretch and limber your muscles before heavy exertion. This hazard becomes more predominant in the early morning hours (prior to muscles becoming limber) and later in the day (as a result of fatigue).

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- Job rotation – Share the duties so that repetitive actions do not result in fatigue and injury.
- Increase break frequencies as needed, especially as ambient conditions of heat and/or cold stress may dictate.
- Do not force the hand tools or use cheater pipes or similar devices to bypass an obstruction. Move to another location near the sampling point. Exerting additional forces on the sampling devices can result in damage and/or failure that could potentially injure someone in the immediate vicinity.
- Do not over compromise yourself when applying force to the soil corer or hand auger. If there is a sudden release, it could result in a fall or muscle injury due to strain.

6.6 Subsurface Soil Sampling with a Split-Barrel Sampler

A split-barrel (split-spoon) sampler consists of a heavy carbon steel or stainless steel sampling tube that can be split into two equal halves to reveal the soil sample (see Attachment B). A drive head is attached to the upper end of the tube and serves as a point of attachment for the drill rod. A removable tapered nosepiece/drive shoe attaches to the lower end of the tube and facilitates cutting. A basket-like sample retainer can be fitted to the lower end of the split tube to hold loose, dry soil samples in the tube when the sampler is removed from the drill hole. This split-barrel sampler is made to be attached to a drill rod and forced into the ground by means of a 140-pound or larger casing driver.

Safety Reminder

It is intended through the Equipment Inspection for Drill Rigs form provided in the HASP that the hammer and hemp rope, where applicable, associated with this activity will be inspected (no physical damage is obvious), properly attached to the hammer (suitable knots or sufficient mechanical devices), and is in overall good condition.

Split-barrel samplers are used to collect soil samples from a wide variety of soil types and from depths greater than those attainable with other soil sampling equipment.

The following equipment is used for obtaining split-barrel samples:

- Drilling equipment (provided by subcontractor).
- Split-barrel samplers (2-inch OD, 1-3/8-inch ID, either 20 inches or 26 inches long); Larger OD samplers are available if a larger volume of sample is needed.
- Drive weight assembly, 140-pound weight, driving head, and guide permitting free fall of 30 inches.
- Stainless steel mixing bowls.
- Equipment listed in Section 6.3.

The following steps shall be followed to obtain split-barrel samples (Steps 1 through 4 are typically performed by the drilling subcontractor):

1. Attach the split-barrel sampler to the sampling rods.

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2. Lower the sampler into the borehole inside the hollow stem auger bits.
3. Advance the split-barrel sampler by hammering the length (typically 18 or 24 inches) of the split-barrel sampler into the soil using 140-pound or larger hammer.
4. When the desired depth is achieved, extract the drill rods and sampler from the augers and/or borehole.
5. Detach the sampler from the drill rods.
6. Place the sampler securely in a vise so it can be opened using pipe wrenches.

CAUTION

Pipe wrenches are used to separate the split spoon into several components. The driller's helper should not apply excessive force through the use of cheater pipes or push or pull in the direction where, if the wrench slips, hands or fingers will be trapped against an immovable object.

7. Remove the drive head and nosepiece with the wrenches, and open the sampler to reveal the soil sample.
8. Immediately scan the sample core with a real-time air monitoring instrument (e.g., FID, PID, etc.) (as project-specific planning documents dictate). Carefully separate (or cut) the soil core, with a decontaminated stainless steel knife or trowel, at about 6-inch intervals while scanning the center of the core for elevated readings. Also scan stained soil, soil lenses, and anomalies (if present), and record readings.
9. If elevated vapor readings were observed, collect the sample scheduled for volatile analysis from the center of the core where elevated readings occurred. If no elevated readings were encountered, the sample material should be collected from the core's center (this area represents the least disturbed area with minimal atmospheric contact) (refer to Section 6.2.1).
10. Using the same trowel, remove remaining sample material from the split-barrel sampler (except for the small portion of disturbed soil usually found at the top of the core sample) and place the soil into a decontaminated stainless steel mixing bowl.
11. Homogenize the sample material as thoroughly as practicable then fill the remaining sample containers (refer to Section 6.2.2).
12. Follow steps 4 through 7 in Section 6.3.

6.7 Subsurface Soil Sampling Using Direct-Push Technology

Subsurface soil samples can be collected to depths of 40+ feet using DPT. DPT equipment, responsibilities, and procedures are described in SOP SA-2.5.

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6.8 **Excavation and Sampling of Test Pits and Trenches**

6.8.1 **Applicability**

This subsection presents routine test pit or trench excavation techniques and specialized techniques that are applicable under certain conditions.

CAUTION

During the excavation of trenches or pits at hazardous waste sites, several health and safety concerns arise from the method of excavation. No personnel shall enter any test pit or excavation over 4 feet deep except as a last resort, and then only under direct supervision of a Competent Person (as defined in 29 CFR 1929.650 of Subpart P - Excavations). Whenever possible, all required chemical and lithological samples should be collected using the excavator bucket or other remote sampling apparatus. If entrance is required, all test pits or excavations must be stabilized by bracing the pit sides using specifically designed wooden, steel, or aluminum support structures or through sloping and benching. Personnel entering the excavation may be exposed to toxic or explosive gases and oxygen-deficient environments; therefore, monitoring will be conducted by the Competent Person to determine if it is safe to enter. Any entry into a trench greater than 4 feet deep will constitute a Confined Space Entry and must be conducted in conformance with OSHA standard 29 CFR 1910.146. In all cases involving entry, substantial air monitoring, before entry, appropriate respiratory gear and protective clothing determination, and rescue provisions are mandatory. There must be at least three people present at the immediate site before entry by one of the field team members. This minimum number of people will increase based on the potential hazards or complexity of the work to be performed. The reader shall refer to OSHA regulations 29 CFR 1926.650, 29 CFR 1910.120, 29 CFR 1910.134, and 29 CFR 1910.146. High-hazard entries such as this will be supported by members of the Health Sciences Group professionally trained in these activities.

Excavations are generally not practical where a depth of more than about 15 to 20-feet is desired, and they are usually limited to a few feet below the water table. In some cases, a pumping system may be required to control water levels within the pit, providing that pumped water can be adequately stored or disposed. If soil data at depths greater than 15-feet are required, the data are usually obtained through test borings instead of test pits.

In addition, hazardous wastes may be brought to the surface by excavation equipment. This material, whether removed from the site or returned to the subsurface, must be properly handled according to any and all applicable federal, state, and local regulations.

6.8.2 **Test Pit and Trench Excavation**

Test pits or trench excavations are constructed with the intent that they will provide an open view of subsurface lithology and/or disposal conditions that a boring will not provide. These procedures describe the methods for excavating and logging test pits and trenches installed to determine subsurface soil and rock conditions. Test pit operations shall be logged and documented (see Attachment C).

Test pits and trenches may be excavated by hand or power equipment to permit detailed descriptions of the nature and contamination of the in-situ materials. The size of the excavation will depend primarily on the following:

- The purpose and extent of the exploration

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- The space required for efficient excavation
- The chemicals of concern
- The economics and efficiency of available equipment

Test pits normally have a cross section that is 4 to 10 feet square; test trenches are usually 3 to 6 feet wide and may be extended for any length required to reveal conditions along a specific line. The following table provides guidelines for design consideration based on equipment efficiencies.

Equipment	Typical Widths, in Feet
Trenching machine	0.25 to 1.0
Backhoe/Track Hoe	2 to 6

The lateral limits of excavation of trenches and the position of test pits shall be carefully marked on area base maps. If precise positioning is required to indicate the location of highly hazardous materials, nearby utilities, or dangerous conditions, the limits of the excavation shall be surveyed. Also, if precise determination of the depth of buried materials is needed for design or environmental assessment purposes, the elevation of the ground surface at the test pit or trench location shall also be determined by survey. If the test pit/trench will not be surveyed immediately, it shall be backfilled and its position identified with stakes placed in the ground at the margin of the excavation for later surveying.

The construction of test pits and trenches shall be planned and designed in advance as much as possible. However, the following field conditions may necessitate revisions to the initial plans:

- Subsurface utilities
- Surface and subsurface encumbrances
- Vehicle and pedestrian traffic patterns
- Purpose for excavation (e.g., the excavation of potential ordnance items)

The final depth and construction method shall be collectively determined by the FOL and designated Competent Person. The actual layout of each test pit, temporary staging area, and spoils pile may further be predicated based on site conditions and wind direction at the time the test pit is excavated. Prior to excavation, the area may be surveyed by magnetometer or metal detector or other passive methods specified in SOP HS1.0, Utility Location and Excavation Clearance, to identify the presence of underground utilities or drums. Where possible, the excavator should be positioned upwind and preferably within an enclosed cab.

No personnel shall enter any test pit or excavation except as a last resort, and then only under direct supervision of a Competent Person. If entrance is required, OSHA requirements must be met (e.g., walls must be braced with wooden or steel braces, ladders must be placed for every 25 feet of lateral travel and extended 3 feet above ground surface). A temporary guard rail or vehicle stop must be placed along the surface of the hole before entry in situations where the excavation may be approached by traffic. Spoils will be stockpiled no closer than 2 feet from the sidewall of the excavation. The excavation equipment operator shall be careful not to undercut sidewalls and will, where necessary, bench back to increase stability. The top cover, when considered clean, will be placed separately from the subsurface materials to permit clean cover. It is emphasized that the project data needs should be structured such that required samples can be collected without requiring entrance into the excavation. For example,

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samples of leachate, groundwater, or sidewall soil can be collected with telescoping poles or similar equipment.

Dewatering and watering may be required to ensure the stability of the side walls, to prevent the bottom of the pit from heaving, and to keep the excavation stable. This is an important consideration for excavations in cohesionless material below the groundwater table and for excavations left open greater than a day. Liquids removed as a result of dewatering operations must be handled as potentially contaminated materials. Procedures for the collection and disposal of such materials should be discussed in the site-specific project plans.

Where possible excavations and test pits shall be opened and closed within the same working day. Where this is not possible, the following engineering controls shall be put in place to control access:

- Trench covers/street plates
- Fences encompassing the entire excavation intended to control access
- Warning signs warning personnel of the hazards
- Amber flashing lights to demarcate boundaries of the excavation at night

Excavations left open will have emergency means to exit should someone accidentally enter.

6.8.3 Sampling in Test Pits and Trenches

6.8.3.1 General

Log test pits and trenches as they are excavated in accordance with the Test Pit Log presented in Attachment C. These records include plan and profile sketches of the test pit/trench showing materials encountered, their depth and distribution in the pit/trench, and sample locations. These records also include safety and sample screening information.

Entry of test pits by personnel is extremely dangerous, shall be avoided unless absolutely necessary, and can occur only after all applicable health and safety and OSHA requirements have been met as stated above. These provisions will be reiterated as appropriate in the project-specific HASP.

The final depth and type of samples obtained from each test pit will be determined at the time the test pit is excavated. Sufficient samples are usually obtained and analyzed to quantify contaminant distribution as a function of depth for each test pit. Additional samples of each waste phase and any fluids encountered in each test pit may also be collected.

In some cases, samples of soil may be extracted from the test pit for reasons other than waste sampling and chemical analysis, for instance, to obtain geotechnical information. Such information includes soil types, stratigraphy, strength, etc., and could therefore entail the collection of disturbed (grab or bulk) or relatively undisturbed (hand-carved or pushed/driven) samples that can be tested for geotechnical properties. The purposes of such explorations are very similar to those of shallow exploratory or test borings, but often test pits offer a faster, more cost-effective method of sampling than installing borings.

6.8.3.2 Sampling Equipment

The following equipment is needed for obtaining samples for chemical or geotechnical analysis from test pits and trenches:

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- Backhoe or other excavating machinery.
- Shovels, picks, hand augers, and stainless steel trowels/disposable trowels.
- Sample container - bucket with locking lid for large samples; appropriate bottle ware for chemical or geotechnical analysis samples.
- Polyethylene bags for enclosing sample containers; buckets.
- Remote sampler consisting of 10-foot sections of steel conduit (1-inch-diameter), hose clamps, and right angle adapter for conduit (see Attachment D).

6.8.3.3 Sampling Methods

The methods discussed in this section refer to test pit sampling from grade level. If test pit entry is required, see Section 6.8.3.4.

- Excavate the trench or pit in several 0.5- to 1.0-foot depth increments. Where soil types support the use of a sand bar cutting plate, use of this device is recommended to avoid potentially snagging utilities with the excavator teeth. It is recommended that soil probes or similar devices be employed where buried items or utilities may be encountered. This permits the trench floor to be probed prior to the next cut.
- After each increment:
 - the operator shall wait while the sampler inspects the test pit from grade level
 - the sampler shall probe the next interval where this is considered necessary. Practical depth increments for lithological evaluations may range from 2 to 4 feet i or where lithological changes are noted.
- The backhoe operator, who will have the best view of the test pit, shall immediately cease digging if:
 - Any fluid phase, including groundwater seepage, is encountered in the test pit
 - Any drums, other potential waste containers, obstructions, or utility lines are encountered
 - Distinct changes of material being excavated are encountered

This action is necessary to permit proper sampling of the test pit and to prevent a breach of safety protocol. Depending on the conditions encountered, it may be required to excavate more slowly and carefully with the backhoe.

For obtaining test pit samples from grade level, the following procedure shall be followed:

- Use the backhoe to remove loose material from the excavation walls and floor to the greatest extent possible.
- Secure the walls of the pit, if necessary. (There is seldom any need to enter a pit or trench that would justify the expense of shoring the walls. All observations and samples should be taken from the ground surface.)

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- Samples of the test pit material are to be obtained either directly from the backhoe bucket or from the material after it has been deposited on the ground, as follows:
 - a. The sampler or FOL shall direct the backhoe operator to remove material from the selected depth or location within the test pit/trench.
 - b. The backhoe operator shall bring the bucket over to a designated location on the sidewall a sufficient distance from the pit (at least 5 feet) to allow the sampler to work around the bucket.
 - c. After the bucket has been set on the ground, the backhoe operator shall either disengage the controls or shut the machine down.
 - d. When signaled by the operator that it is safe to do, the sampler will approach the bucket.
 - e. The soil shall be monitored with a photoionization or flame ionization detector (PID or FID) as directed in the project -specific planning documents.
 - f. The sampler shall collect the sample from the center of the bucket or pile in accordance with surface soil sampling procedures of Section 6.3 or 6.4, as applicable. Collecting samples from the center of a pile or bucket eliminates cross-contamination from the bucket or other depth intervals.
- If a composite sample is desired, several depths or locations within the pit/trench will be selected, and the bucket will be filled from each area. It is preferable to send individual sample bottles filled from each bucket to the laboratory for compositing under the more controlled laboratory conditions. However, if compositing in the field is required, each sample container shall be filled from materials that have been transferred into a mixing bucket and homogenized. Note that homogenization/compositing is not applicable for samples to be subjected to volatile organic analysis.

CAUTION

Care must be exercised when using the remote sampler described in the next step because of potential instability of trench walls. In situations where someone must move closer than 2 feet to the excavation edge, a board or platform should be used to displace the sampler's weight to minimize the chance of collapse of the excavation edge. Fall protection should also be employed when working near the edges or trenches greater than 6 feet deep. An immediate means to extract people who have fallen into the trench will be immediately available. These means may include ladders or rope anchor points.

- Using the remote sampler shown in Attachment D, samples can be taken at the desired depth from the sidewall or bottom of the pit as follows:
 - a. Scrape the face of the pit/trench using a long-handled shovel or hoe to remove the smeared zone that has contacted the backhoe bucket.
 - b. Collect the sample directly into the sample jar, by scraping with the jar edge, eliminating the need for sample handling equipment and minimizing the likelihood of cross-contamination.
 - c. Cap the sample jar, remove it from the remote sampler assembly, and package the sample for shipment in accordance with SOP SA-6.3.
- Complete documentation as described in SOP SA-6.3 and Attachment C of this SOP.

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6.8.3.4 In-Pit Sampling

Under rare conditions, personnel may be required to enter the test pit/trench. This is necessary only when soil conditions preclude obtaining suitable samples from the backhoe bucket (e.g., excessive mixing of soil or wastes within the test pit/trench) or when samples from relatively small discrete zones within the test pit are required. This approach may also be necessary to sample any seepage occurring at discrete levels or zones in the test pit that are not accessible with remote samplers.

In general, personnel shall sample and log pits and trenches from the ground surface, except as provided for by the following criteria:

- There are no practical alternative means of obtaining such data.
- The SSO and Competent Person determine that such action can be accomplished without breaching site safety protocol. This determination will be based on actual monitoring of the pit/trench after it is dug (including, at a minimum, measurements of oxygen concentration, flammable gases, and toxic compounds, in that order). Action levels will be provided in project-specific planning documents.
- A company-designated Competent Person determines that the pit/trench is stable through soil classification evaluation/inspections or is made stable (by cutting/grading the sidewalls or using shoring) prior to entrance of any personnel. OSHA requirements shall be strictly observed.

If these conditions are satisfied, only one person may enter the pit/trench. On potentially hazardous waste sites, this individual shall be dressed in selected PPE as required by the conditions in the pit. He/she shall be affixed to a harness and lifeline and continuously monitored while in the pit.

A second and possible third individual shall be fully dressed in protective clothing including a self-contained breathing device and on standby during all pit entry operations to support self rescue or assisted self rescue. The individual entering the pit shall remain therein for as brief a period as practical, commensurate with performance of his/her work. After removing the smeared zone, samples shall be obtained with a decontaminated trowel or spoon.

6.8.3.5 Geotechnical Sampling

In addition to the equipment described in Section 6.8.3.2, the following equipment is needed for geotechnical sampling:

- Soil sampling equipment, similar to that used in shallow drilled boring (i.e., thin-walled tube samplers), that can be pushed or driven into the floor of the test pit.
- Suitable driving (e.g., sledge hammer) or pushing (e.g., backhoe bucket) equipment used to advance the sampler into the soil.
- Knives, spatulas, and other suitable devices for trimming hand-carved samples.
- Suitable containers (bags, jars, tubes, boxes, etc.), labels, wax, etc. for holding and safely transporting collected soil samples.
- Geotechnical equipment (pocket penetrometer, torvane, etc.) for field testing collected soil samples for classification and strength properties.

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Disturbed grab or bulk geotechnical soil samples may be collected for most soil in the same manner as comparable soil samples for chemical analysis. These collected samples may be stored in jars or plastic-lined sacks (larger samples), which will preserve their moisture content. Smaller samples of this type are usually tested for their index properties to aid in soil identification and classification: larger bulk samples are usually required to perform compaction tests.

Relatively undisturbed samples are usually extracted in cohesive soil using thin-walled tube samplers, and such samples are then tested in a geotechnical laboratory for their strength, permeability, and/or compressibility. The techniques for extracting and preserving such samples are similar to those used in performing Shelby tube sampling in borings, except that the sampler is advanced by hand or backhoe, rather than by a drill rig. Also, the sampler may be extracted from the test pit by excavation around the tube when it is difficult to pull it out of the ground. If this excavation requires entry of the test pit, the requirements described in Section 6.8.3.4 shall be followed. The thin-walled tube sampler shall be pushed or driven vertically into the floor or steps excavated in the test pit at the desired sampling elevations. Extracting tube samples horizontally from the walls of the test pit is not appropriate because the sample will not have the correct orientation.

A sledge hammer or backhoe may be used to drive or push the tube into the ground. Place a piece of wood over the top of the sampler or sampling tube to prevent damage during driving/pushing of the sample. Pushing the sampler with a constant thrust is always preferable to driving it with repeated blows, thus minimizing disturbance to the sample. When using a sledge hammer, it is recommended that the sampler be stabilized using a rope/strap wrench or pipe wrench to remove the person's hands holding the sampler from the strike zone. If the sample cannot be extracted by rotating it at least two revolutions (to shear off the sample at the bottom), hook the sampler to the excavator or backhoe and extract. This means an alternative head will be used as a connection point or that multiple choke hitches will be applied to extract the sampler. If this fails and the excavator can dig deeper without potentially impacting subsurface utilities, excavate the sampler. If this fails or if the excavator cannot be used due to subsurface utilities, hand-excavate to remove the soil from around the sides of the sampler. If hand-excavation requires entry into the test pit, the requirements in Section 6.8.3.4 must be followed. Prepare the sample as described in Steps 9 through 13 in Section 6.2.3, and label, pack and transport the sample in the required manner, as described in SOPs SA-6.3 and SA-6.1.

6.8.4 Backfilling of Trenches and Test Pits

All test pits and excavations must be either backfilled, covered, or otherwise protected at the end of each day. No excavations shall remain open during non-working hours unless adequately covered or otherwise protected.

Before backfilling, the onsite crew may photograph, if required by the project-specific work plan, all significant features exposed by the test pit and trench and shall include in the photograph a scale to show dimensions. Photographs of test pits shall be marked to include site number, test pit number, depth, description of feature, and date of photograph. In addition, a geologic description of each photograph shall be entered in the site logbook. All photographs shall be indexed and maintained as part of the project file for future reference.

After inspection, backfill material shall be returned to the pit under the direction of the FOL. Backfill should be returned to the trench or test pit in 6-inch to 1-foot lifts and compacted with the bucket. Remote controlled tampers or rollers may be lowered into the trench and operated from top side. This procedure will continue to the grade surface. It is recommended that the trench be tracked or rolled in. During excavation, clean soil from the top 2 feet may have been separated to be used to cover the last segments. Where these materials are not clean, it is recommended that clean fill be used for the top cover.

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If a low-permeability layer is penetrated (resulting in groundwater flow from an upper contaminated flow zone into a lower uncontaminated flow zone), backfill material must represent original conditions or be impermeable. Backfill could consist of a soil-bentonite mix prepared in a proportion specified by the FOL (representing a permeability equal to or less than original conditions). Backfill can be covered by "clean" soil and graded to the original land contour. Revegetation of the disturbed area may also be required.

6.9 Records

The appropriate sample log sheet (see Attachment A of this SOP) must be completed by the site geologist/sampler for all samples collected. All soil sampling locations should be documented by tying in the location of two or more nearby permanent landmarks (building, telephone pole, fence, etc.) or obtaining GPS coordinates; and shall be noted on the appropriate sample log sheet, site map, or field notebook. Surveying may also be necessary, depending on the project requirements.

Test pit logs (see Attachment C of this SOP) shall contain a sketch of pit conditions. If the project-specific work plan requires photographs, at least one photograph with a scale for comparison shall be taken of each pit. Included in the photograph shall be a card showing the test pit number. Boreholes, test pits, and trenches shall be logged by the field geologist in accordance with SOP GH-1.5.

Other data to be recorded in the field logbook include the following:

- Name and location of job
- Date of boring and excavation
- Approximate surface elevation
- Total depth of boring and excavation
- Dimensions of pit
- Method of sample acquisition
- Type and size of samples
- Soil and rock descriptions
- Photographs if required
- Groundwater levels
- PID/FID/LEL/O₂ meter readings
- Other pertinent information, such as waste material encountered

In addition, site-specific documentation to be maintained by the SSO and/or Competent Person will be required including:

- Calibration logs
- Excavation inspection checklists

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- Soil type classification

7.0 REFERENCES

American Society for Testing and Materials, 1987. ASTM Standards D1587-83 and D1586-84. ASTM Annual Book of Standards. ASTM. Philadelphia, Pennsylvania. Volume 4.08.

NUS Corporation, 1986. Hazardous Material Handling Training Manual.

NUS Corporation and CH2M Hill, August, 1987. Compendium of Field Operation Methods. Prepared for the U.S. EPA.

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USEPA, November 2001. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual.

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ATTACHMENT A **SOIL & SEDIMENT SAMPLE LOG SHEET**



Tetra Tech NUS, Inc.

SOIL & SEDIMENT SAMPLE LOG SHEET

Page ____ of ____

Project Site Name: _____	Sample ID No.: _____
Project No.: _____	Sample Location: _____
<input type="checkbox"/> Surface Soil	Sampled By: _____
<input type="checkbox"/> Subsurface Soil	C.O.C. No.: _____
<input type="checkbox"/> Sediment	Type of Sample:
<input type="checkbox"/> Other: _____	<input type="checkbox"/> Low Concentration
<input type="checkbox"/> QA Sample Type: _____	<input type="checkbox"/> High Concentration

GRAB SAMPLE DATA:

Date:	Depth	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Time:			
Method:			
Monitor Reading (ppm):			

COMPOSITE SAMPLE DATA:

Date:	Time	Depth	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Method:				
Monitor Readings (Range in ppm):				

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other

OBSERVATIONS / NOTES:

MAP:

--	--

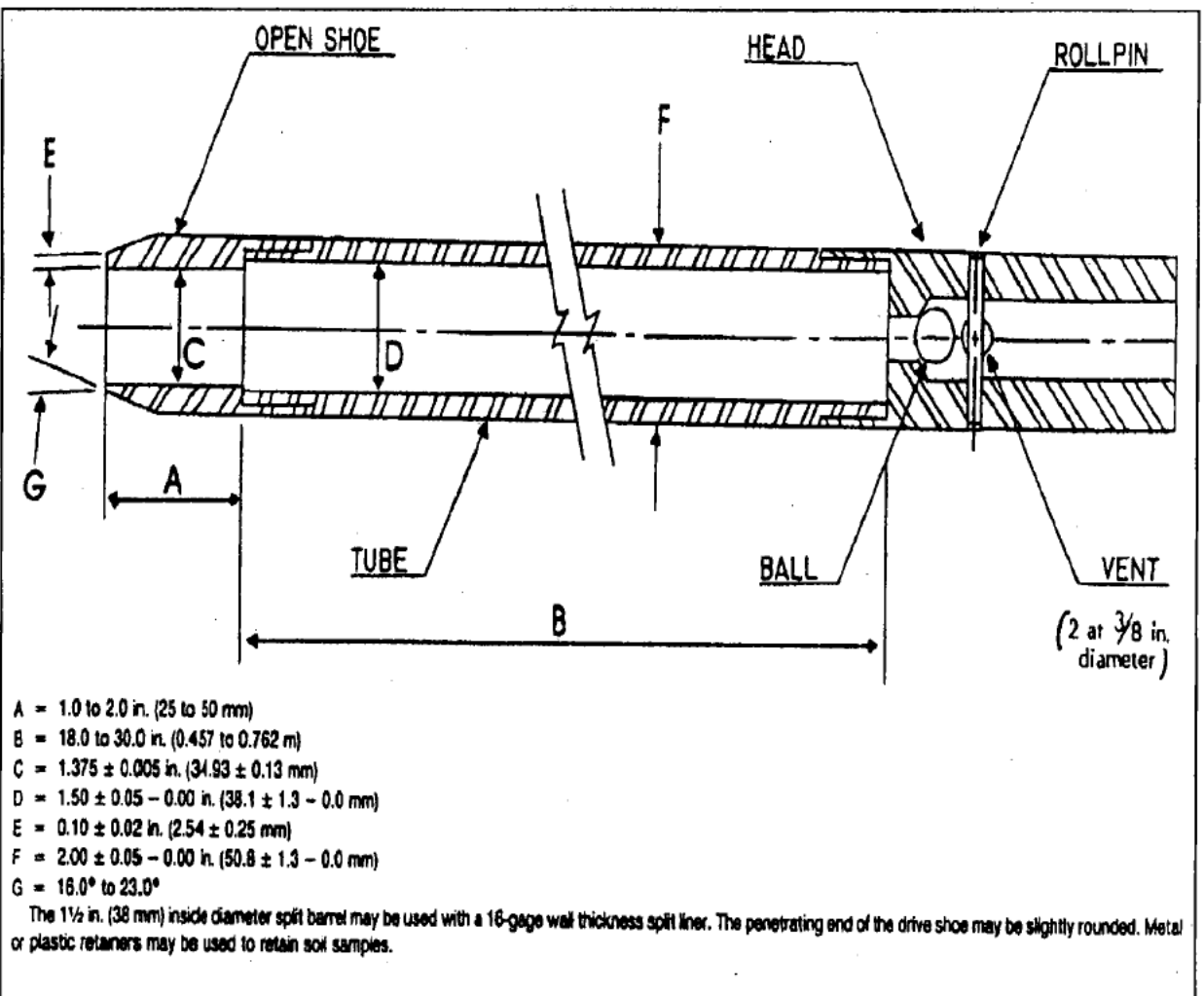
Circle if Applicable:

Signature(s):

MS/MSD	Duplicate ID No.:	
--------	-------------------	--

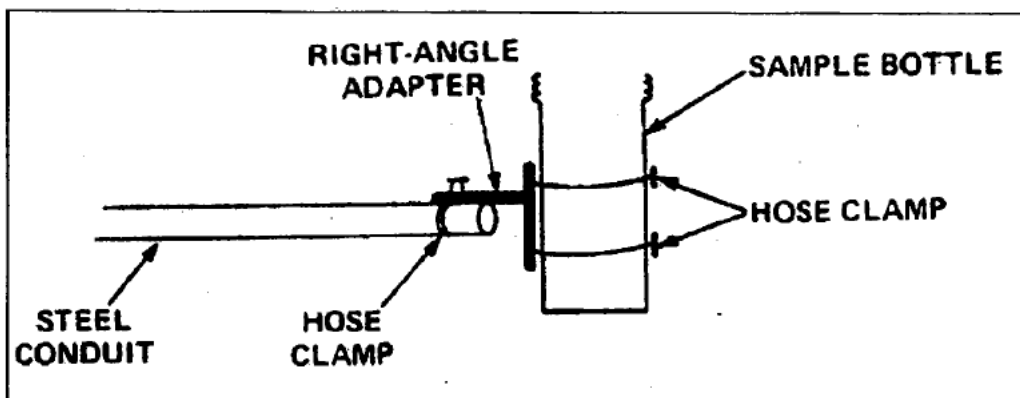
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ATTACHMENT B SPLIT-SPOON SAMPLER



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**ATTACHMENT D
REMOTE SAMPLE HOLDER FOR TEST PIT/TRENCH SAMPLING**





STANDARD OPERATING PROCEDURES

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Effective Date	01/28/2009	Revision	6
Applicability	Tetra Tech NUS, Inc.		
Prepared	Earth Sciences Department		
Approved	Tom Johnston <i>T.E. Johnston</i>		

Subject DECONTAMINATION OF FIELD EQUIPMENT

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1.0 PURPOSE

Decontamination is the process of removing and/or neutralizing site contaminants that have contacted and/or accumulated on equipment. The purpose of this Standard Operating Procedure (SOP) is to protect site personnel, the general public, and the environment while preserving or maintaining sample integrity. It is further intended through this procedure to describe the steps necessary for proper decontamination of drilling equipment, earth-moving equipment, chemical sampling equipment and field operation and analytical equipment.

2.0 SCOPE AND APPLICABILITY

This procedure applies to all equipment used to provide access to/acquire environmental samples that may have become contaminated through direct contact with contaminated media including air, water, and soil. This equipment includes drilling and heavy equipment and chemical sampling and field analytical equipment. Where technologically and economically feasible, single-use sealed disposable equipment will be employed to minimize the potential for cross-contamination. This SOP also provides general reference information on the control of contaminated materials.

Decontamination methods and equipment requirements may differ from one project to another. General equipment items are specified in Section 6.0, but project-specific equipment must be obtained to address the project-specific decontamination procedures presented in Section 7.0 and applicable subsections.

3.0 GLOSSARY

Alconox/Liquinox - A brand of phosphate-free laboratory-grade detergent.

Decontamination Solution - A solution selected/identified in the Health and Safety Plan or Project-Specific Quality Assurance Plan. The solution is selected and employed as directed by the project chemist/health and safety professional.

Deionized Water (DI) - Tap water that has been treated by passing through a standard deionizing resin column. This water may also pass through additional filtering media to attain various levels of analyte-free status. The DI water should meet College of American Pathologists (CAP) and National Committee for Clinical Laboratory Standards (NCCLS) specifications for reagent-grade Type I water.

Potable Water - Tap water from any municipal water treatment system. Use of an untreated potable water supply is not an acceptable substitute for tap water.

Pressure Washing - Process employing a high-pressure pump and nozzle configuration to create a high-pressure spray of potable water. High-pressure spray is employed to remove solids from equipment.

Solvent – A liquid in which solid chemicals or other liquids are dissolved. The solvent of choice is pesticide-grade isopropanol. Use of other solvents (methanol, acetone, or hexane) may be required for particular projects or for a particular purpose (e.g., removal of concentrated waste) and must be justified in the project planning documents. For example, it may be necessary to use hexane when analyzing for trace levels of pesticides, PCBs, or fuels. In addition, because many of these solvents are not miscible in water, the equipment should be air dried prior to use. Solvents should not be used on PVC equipment or well construction materials.

Steam Pressure Washing - A cleaning method employing a high-pressure spray of heated potable water to remove various organic/inorganic chemicals from equipment.

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4.0 RESPONSIBILITIES AND PERSONNEL QUALIFICATIONS

Project Manager - Responsible for ensuring that all field activities are conducted in accordance with approved project plan(s) requirements.

Decontamination Personnel - Individuals assigned the task of decontamination. It is the responsibility of these individuals to understand the use and application of the decontamination process and solutions as well as the monitoring of that process to ensure that it is working properly. This is accomplished through visual evaluation, monitoring instrument scanning of decontaminated items, and/or through the collection of rinsate blanks to verify contaminant removal.

Field Operations Leader (FOL) - Responsible for the implementation of project-specific planning documents. This includes on-site verification that all field activities are performed in compliance with approved SOPs or as otherwise dictated by the approved project plan(s). The FOL is also responsible for the completion and accuracy of all field documentation.

Site Safety Officer (SSO) - Exercises shared responsibility with the FOL concerning decontamination effectiveness. All equipment arriving on site (as part of the equipment inspection), leaving the site, and moving between locations is required to go through a decontamination evaluation. This is accomplished through visual examination and/or instrument screening to determine the effectiveness of the decontamination process. Improper or incomplete decontamination is sufficient to restrict equipment from entering the site, exiting the site, or moving to a new location on the site until the objectives are successfully completed.

General personnel qualifications for decontamination activities include the following:

- Occupational Safety and Health Administration (OSHA) 40-hour and applicable refresher training.
- Capability of performing field work under the expected physical and environmental (i.e., weather) conditions.
- Familiarity with appropriate decontamination procedures.

5.0 HEALTH AND SAFETY

In addition to the health and safety issues and reminders specified in subsections of this SOP, the following considerations and requirements must be observed as SOPs for field equipment decontamination activities:

- If any solvents or hazardous chemicals (e.g., isopropyl alcohol) are to be used in equipment decontamination activities, the FOL must first obtain the manufacturer's/supplier's Material Safety Data Sheet (MSDS) and assure that it is reviewed by all users (prior to its use), added to the site Hazardous Chemical Inventory, and maintained on site as part of the project Hazard Communication Program.
- Review and observe specific health and safety requirements (e.g., personal protective equipment [PPE]) specified in the project-specific health and safety plan for this activity.

6.0 EQUIPMENT LIST

- Wood for decontamination pad construction, when applicable (see Section 7.1).

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- Tools for constructing decontamination pad frame, when applicable (see Section 7.1).
- Visqueen sheeting or comparable material to cover decontamination pad frame, when applicable (see Section 7.1).
- Wash/drying racks for auger flights and drill/drive rods, when applicable (see Section 7.2).
- PPE as specified in the project health and safety plan.
- Soap and water for washing and rinsing.
- Deionized water for final rinsing.
- Solvents (e.g., pesticide-grade isopropanol) for rinsing (see applicable portions of Section 7.2).
- Tubs, buckets, etc. for containerizing rinse water (see applicable portions of Section 7.2).
- Sample bottles for collecting rinsate blanks (see Section 7.2).
- Calibrated photoionization detector (PID) or flame ionization detector (FID) to monitor decontaminated equipment for organic vapors generated through the existence of residual contamination or the presence of decontamination solvent remaining after the piece was rinsed.
- Aluminum foil or clear clean plastic bag for covering cleaned equipment (see applicable portions of Section 7.2).
- Paper towels or cloths for wiping.
- Brushes, scrapers, or other hand tools useful for removing solid materials from equipment.
- Clear plastic wrap for covering or wrapping large decontaminated equipment items (see Section 7.2.2).
- Drum-moving equipment for moving filled waste drums (optional) (see Section 7.3).
- Drum labels for waste drums (see Attachment A).

7.0 PROCEDURES

The process of decontamination is accomplished through the removal of contaminants, neutralization of contaminants, or isolation of contaminants. To accomplish this activity, preparation is required including site preparation, equipment selection, and evaluation of the decontamination requirements and processes. Site contaminant types, concentrations, and media types are primary drivers in the selection of the types of decontamination and where it will be conducted. For purposes of this SOP, discussion is limited to decontamination procedures for general environmental investigations.

Decontamination processes will be performed at the location(s) specified in project-specific planning documents. Typical decontamination locations include the following:

- Temporary decontamination pads/facilities
- Sample locations
- Centralized decontamination pad/facilities

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- Combination of some or all of the above

The following discussion includes general considerations for the decontamination process. Specific construction and implementation procedures will be as specified in the project-specific planning documents and/or may be as dictated by site-specific conditions as long as the intent of the requirements in the planning documents is met. This intent is to contain any residual fluids and solids generated through the decontamination process.

7.1 Decontamination Pad Design/Construction Considerations

7.1.1 Temporary Decontamination Pads

Temporary decontamination pads may be constructed at satellite locations within the site area in support of temporary work areas. These structures are generally constructed to support the decontamination of heavy equipment such as drill rigs and earth-moving equipment but can be employed for smaller articles.

The purpose of the decontamination pad is to contain wash waters and potentially contaminated soil generated during decontamination procedures. Therefore, construction of these pads should take into account the following considerations:

- Site location – The decontamination site selected should be far enough from the work site to maximize decontamination effectiveness while minimizing travel distance. The location of the decontamination site shall be selected to provide, in the judgment of the FOL or FOL designee, compliance with as many of the following characteristics as practicable:
 - Well removed from pedestrian/vehicle thoroughfares.
 - Avoidance of areas where control/custody cannot be maintained.
 - Avoidance of areas where potential releases of contaminated media or decontamination fluids may be compounded through access to storm water transport systems, streams, or other potentially sensitive areas.
 - Avoidance of potentially contaminated areas.
 - Avoidance of areas too close to the ongoing operation, where cross-contamination may occur.

The selected decontamination site should include the following, where possible:

- Areas where potable water and electricity are provided.

Safety Reminder

When utilizing electrical power sources, either hard-wired or portable-generated sources, ensure that:

- All power is routed through a Ground Fault Circuit Interrupter (GFCI).
- All power cords are in good condition (no physical damage), rated for the intended energy load, and designated for outdoor use.

In situations where accomplishing these elements is not possible, it will be necessary to implement a site electrical grounding program.

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- Areas where support activities such as removing decontamination waters soil and sediment are possible without entering an active exclusion zone.
- Areas that offer sufficient size to carry out the specific decontamination sequence.
- Decontamination pad (decon pad) – The decon pad shall be constructed to meet the following characteristics:
 - Size – The size of the pad should be sufficient to accept the equipment to be decontaminated as well as permitting free movement around the equipment by the personnel conducting the decontamination. The size should permit these movements utilizing pressure/steam washer wands and hoses and minimizing splash due to work in close quarters.
 - Slope – An adequate slope will be constructed to permit the collection of water and potentially contaminated soil within a trough or sump constructed at one end. The collection point for wash waters should be of adequate distance that the decontamination workers do not have to walk through the wash waters while completing their tasks. Because the pad will be sloped, place a light coating of sand over the plastic to minimize potential slips and falls. See the text about liners below.
 - Sidewalls – The sidewalls shall be at least 6 inches in height (or as high as possible if 6 inches is not achievable) to provide adequate containment for wash waters and soil. If splash represents a potential problem, splash guards should be constructed to control overspray. Sidewalls may be constructed of wood, inflatables, sand bags, etc. to permit containment. Splash guards are typically wood frames with Visqueen coverings to control overspray.
 - Liner – Depending on the types of equipment and decontamination method to be used, the liner should be of sufficient thickness to provide a puncture-resistant barrier between the decontamination operation and the unprotected environment. Care should be taken to examine the surface area prior to placing the liner to remove sharp articles (sticks, stones, debris) that could puncture the liner. Liners are intended to form an impermeable barrier. The thickness may vary from a minimum recommended thickness of 10 mil to 30 mil. The desired thickness may be achieved through layering materials of lighter construction. It should be noted that various materials (rubber, polyethylene sheeting) become slippery when wet. To minimize this potential hazard associated with a sloped liner, a light coating of sand shall be applied to provide traction as necessary.
 - Wash/drying racks – Auger flights, drill/drive rods, and similar equipment require racks positioned off of the ground to permit these articles to be washed, drained, and dried while secured from falling during this process.

For decontamination of direct-push technology (DPT) equipment, the pad may be as simple as a mortar tub containing buckets of soapy water for washing and an empty bucket to capture rinse waters. Decontamination may be conducted at the rear of the rig to permit rapid tool exchange.

- Maintenance – Maintain the decontamination area by:
 - Periodically clearing the work area of standing water, soil, and debris, and coiling hoses to aid in eliminating slip, trip, and fall hazards. In addition, these articles will reduce potential backsplash and cross-contamination.

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- Regularly changing the decontamination fluids to ensure proper cleaning and prevent cross-contamination.
- PPE – Periodically evaluate the condition of, and maintain the decontamination equipment, including regular cleaning of face shields and safety glasses. This is critical to ensuring the safety of decontamination personnel and the integrity of the decontamination process, and it will ensure that equipment is functioning properly.

7.1.2 Decontamination Activities at Drill Rigs/DPT Units

During subsurface sampling activities including drilling and DPT activities, decontamination of drive rods, Macro Core Samplers, split spoons, etc. is typically conducted at an area adjacent to the operation. Decontamination is generally accomplished using a soap/water wash and rinse utilizing buckets and brushes. This area requires sufficient preparation to accomplish the decontamination objectives.

Buckets shall be placed within mortar tubs or similar secondary containment tubs to prevent splash and spills from reaching unprotected environmental media. Drying racks shall be employed as directed for temporary pads to permit parts to dry and be evaluated prior to use/reuse. Methodology regarding this activity is provided in Section 7.2.

7.1.3 Decontamination Activities at Remote Sample Locations

When sampling at remote locations, sampling equipment such as trowels and pumps/tubing should be evacuated of potentially contaminated media to the extent possible. This equipment should be wrapped in plastic for transport to the temporary/centralized decontamination location for final cleaning and disposition. Flushing and cleaning of single-use equipment such as disposable trowels, tubing, and surgeon's gloves may allow disposal of this equipment after visible soil and water remnants have been removed.

7.2 Equipment Decontamination Procedures

The following represents procedures to be employed for the decontamination of equipment that may have contacted and/or accumulated contamination through site investigation activities.

7.2.1 Monitoring Well Sampling Equipment

7.2.1.1 Groundwater sampling equipment – This includes pumps inserted into monitoring wells such as bladder pumps, Whale pumps, and Redi-Flo pumps and reusable bailers, etc.

1. Evacuate to the extent possible, any purge water within the pump/bailer.
2. Scrub using soap and water and/or steam clean the outside of the pump/bailer and, if applicable, the pump tubing.
3. Insert the pump and tubing/bailer into a clean container of soapy water. Pump/run a sufficient amount of soapy water through the pump/bailer to flush out any residual well water. After the pump is flushed, circulate soapy water through the pump to ensure that the internal components are thoroughly flushed.
4. Remove the pump and tubing/bailer from the container
5. Rinse external pump components using tap water.

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6. Insert the pump and tubing/bailer into a clean container of tap water. Pump/run a sufficient amount of tap water through the pump/bailer to evacuate all of the soapy water (until clear).

CAUTION

Do not rinse PE, PVC, and associated tubing with solvents –
Use the procedures defined in the project-specific planning documents. If they are not defined, contact the FOL for guidance. The solvent rinse described in Step 7 may be omitted if groundwater does not contain oil, grease, PAHs, PCBs, or other hard to remove organic materials.

7. If groundwater contains or is suspected to contain oil, grease, PAHs, PCBs, or other hard to remove organic materials, rinse the equipment to be cleaned with pesticide-grade isopropanol.
8. Pass deionized water through the hose to flush out the tap water and solvent residue as applicable.
9. Drain residual deionized water to the extent possible.
10. Allow components of the equipment to air dry.
11. For bladder pumps, disassemble the pump and wash the internal components with soap and water, then rinse with tap water, isopropanol, and deionized water and allow to dry. After the parts are dry, conduct a visual inspection and a monitoring instrument scan to ensure that potential contaminants and all decontamination solvent have been removed. Collect a rinsate blank in accordance with the project-specific planning documents to ensure that the decontamination process is functioning as intended. The typical frequency of collection for rinsate blanks is 1 per 20 field samples. In addition, wipe samples or field tests such as UV light may be used.
12. Wrap pump/bailer in aluminum foil or a clear clean plastic bag for storage.

SAFETY REMINDER

Remember when handling powered equipment to disconnect the power source and render the equipment to a zero energy state (both potential and kinetic) before opening valves, disconnecting lines, etc.

7.2.1.2 Electronic Water Level Indicators/Sounders/Tapes

During water level measurements, rinsing the extracted tape and probe with deionized water and wiping the surface of the extracted tape between locations is acceptable. However, periodic full decontamination should be conducted as follows:

1. Wash with soap and water
2. Rinse with tap water
3. Rinse with deionized water

NOTE

In situations where oil, grease, free product, other hard to remove materials are encountered, probes and exposed tapes should be washed in hot soapy water. If probes or tapes cannot be satisfactorily decontaminated (they are still stained, discolored, etc.), they should be removed from service.

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7.2.1.3 Miscellaneous Equipment

Miscellaneous equipment including analytical equipment (water quality testing equipment) shall be cleaned per manufacturers' instructions. This generally includes wiping the sensor housing and rinsing with tap and deionized water.

Coolers/shipping containers employed to ship samples are received from the laboratory in a variety of conditions including marginal to extremely poor. Coolers shall be evaluated prior to use for the following:

- Structural integrity – Coolers missing handles or having breaks in the outer housing should be removed and not used. Notify the laboratory that the risk of shipping samples in the cooler(s) provided is too great and request a replacement unit.
- Cleanliness – As per protocol, only volatile organic samples are accompanied by a trip blank. If a cooler's cleanliness is in question (visibly dirty/stained) or if there are noticeable odors, the cooler should be decontaminated prior to use as follows:
 1. Wash with soap and water
 2. Rinse with tap water
 3. Dry

If these measures fail to clean the cooler to an acceptable level, remove the unit from use as a shipping container and ask the cooler provider (e.g., the analytical laboratory) to provide a replacement unit.

7.2.2 **Downhole Drilling Equipment**

This includes any portion of the drill rig that is over the borehole, including auger flights, drill stems, rods, and associated tooling that would extend over the borehole. The following procedure is to be employed prior to initiating the drilling/sampling activity, then between locations:

CAUTION

Exercise care when using scrapers to remove soil and debris from downhole drilling equipment. Inadvertent slips of scrapers have resulted in cuts, scrapes, and injured knuckles, so use scrapers carefully when removing soil from these items.

1. Remove loose soil using shovels, scrapers, etc.
2. Through a combination of scrubbing using soap and water and/or steam cleaning or pressure washing, remove visible dirt/soil from the equipment being decontaminated.

CAUTION

In Step 3, do not rinse PE, PVC, and associated tubing with solvents. The appropriate procedures should be defined within the project-specific planning documents. If they are not defined, contact the FOL for guidance. The solvent rinse described in Step 4 may be omitted if groundwater does not contain oil, grease, PAHs, PCBs, or other hard to remove organic materials.

3. Rinse the equipment with tap water, where applicable (steam cleaning and pressure washing incorporate rinsing as part of the process).

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4. If the equipment has directly or indirectly contacted contaminated sample media and is known or suspected of being contaminated with oil, grease, PAHs, PCBs, or other hard to remove organic materials, rinse equipment with pesticide-grade isopropanol
5. To the extent possible, allow components to air dry.
6. If the decontaminated equipment is to be used immediately after decontamination, screen it with a calibrated photoionization detector (PID)/flame ionization detector (FID) to ensure that all contaminants and possible decontamination solvents (if they were used) have been adequately removed.
7. Wrap or cover equipment in clear plastic until it is time to be used.

SAFETY REMINDER

Even when equipment is disconnected from power sources, dangers such as the following may persist:

Falls - An auger flight standing on its end may fall and injure someone. Secure all loose articles to prevent heavy articles from falling onto people or equipment.

Burns - Steam cleaner water is heated to more than 212 °F and exhibits thermal energy that can cause burns. Prevent contact of skin with hot water or surfaces.

High water pressure - Pressure washer discharge can have 2,000 to 4,000 psi of water pressure. Water under this amount of pressure can rupture skin and other human tissues. Water at 4,000 psi exiting a 0° tip can be dangerous because of its relatively high cutting power. The exit velocity and cutting power of the water are reduced when exiting a 40° fan tip, but damage to soft tissues is still possible.

In general, follow the rules below to avoid injury, equipment damage, or incomplete decontamination:

1. Read the operating manual and follow the manufacturers' recommended safety practices before operating pressure washers and steam cleaners.
2. Never point the pressure washer or steam cleaner at another person or use to clean your boots or other parts of your body. Water lacerations and burns may appear to be minor at first but can be life threatening. Do not attempt to hold small parts in your hand while washing them with high-temperature or high-pressure water.
3. Always wear PPE as specified in the HASP such as:
 - Hard hat, safety glasses, splash shield, impermeable apron or splash suit, and hearing protection. Remember that excessive noise is a hazard when operating gas-powered engines and electrically driven pressure washers. PPE will be identified in your project specific planning documents.
4. Inspect each device before use. An inspection checklist will be provided in the project-specific planning documents. If it is a rented device, safety measures are typically provided by the vendor. In all cases, if you are not familiar with the operation of a pressure washer/steam cleaner, do not operate it until you obtain and thoroughly review operating instructions and recommended safety practices.
5. Do not modify equipment unless the manufacturer has approved the modifications.

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		Revision	6	Effective Date	01/28/2009

7.2.3 Soil/Sediment Sampling Equipment

This section applies to soil sampling equipment including but not limited to hand augers, stainless steel trowels/spoons, bowls, dredges, scoops, split spoons, Macro Core samplers, etc.

1. Remove all loose soil from the equipment through manual means.
2. Through a combination of scrubbing using soap and water and/or steam cleaning or pressure washing, remove visible dirt/soil from the equipment.
3. Rinse the equipment with tap water.

CAUTION

Do not rinse PE, PVC, and associated tubing with solvents. The appropriate procedures should be defined within the project-specific planning documents. If they are not defined, contact the FOL for guidance. The solvent rinse described in Step 4 may be omitted if groundwater does not contain oil, grease, PAHs, PCBs, or other hard to remove organic materials.

4. If the equipment is contaminated or suspected to be contaminated with oil, grease, PAHs, PCBs, or other hard to remove organic materials, rinse the equipment with pesticide-grade isopropanol.
5. Rinse the equipment with deionized water.
6. To the extent possible, allow components to air dry.
7. If the equipment is to be used immediately after decontamination, screen it with a calibrated PID/FID to ensure that all solvents (if they were used) and trace contaminants have been adequately removed.
8. After the equipment has dried, wrap it in aluminum foil for storage until use.

Dredges employed in sediment sampling are typically decontaminated as follows:

- Remove the sediment sample from the sampling device
- If sufficient associated surface water is available at the sampling site, place the dredge in the water and flush to remove visible sediment.
- Extract the dredge and wash it in soap and water per the project-specific planning documents.

CAUTION

When handling dredges, the primary safety concern is trapping fingers or extremities in the larger dredge samplers within the jaws or pinch points of the mechanical jaws. Keep hands, fingers, and extremities away from these pinch and compression points. Either handle the device by the rope or preferably lock the jaws in place to control the potential for closing during maintenance and/or cleaning.

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7.3 **Contact Waste/Materials**

During the course of field investigations, disposable/single-use equipment becomes contaminated. These items include tubing, trowels, PPE (gloves, overboots, splash suits, etc.), and broken sample containers.

With the exception of the broken glass, single-use articles should be cleaned (washed and rinsed) of visible materials and disposed as normal refuse. The exception to this rule is that extremely soiled materials that cannot be cleaned shall be containerized for disposal in accordance with applicable federal, state, and local regulations.

7.3.1 **Investigation-Derived Wastes - Decontamination Wash Waters and Sediments**

NOTE

Requirements for waste storage may differ from one facility to the next. Facility-specific directions for waste storage areas will be provided in project-specific documents, or separate direction will be provided by the Project Manager.

1. Assume that all investigation-derived waste (IDW) generated from decontamination activities contains the hazardous chemicals associated with the site unless there are analytical or other data to the contrary. Waste solution volumes could vary from a few gallons to several hundred gallons in cases where large equipment required cleaning.
2. Where possible, use filtering systems to extend the use of water within a closed system wash unit to recycle water and to reduce possible waste amounts.

NOTE

Containerized waste rinse solutions are best stored in 55-gallon drums (or equivalent containers) that can be sealed until ultimate disposal at an approved facility.

3. Label waste storage containers appropriately labeled (see Attachment A).
4. Ensure that the IDW storage area is configured to meet the following specifications to permit access to the containers and to conduct spill/leak monitoring, sampling, and extraction when the disposal route is determined:
 - Enclose areas accessible by the general public using construction fencing and signs.
 - Stored materials in 55-gallon drums on pallets with four (or fewer) drums per pallet.
 - Maintain the retaining bolt and label on the outside of storage containers where readily visible.
 - Provide at least 4 feet of room between each row of pallets to allow access to containers for sampling, drum removal, and spill response.
 - As directed in project-specific planning documents, maintain an IDW Inventory List and provide the list to the site Point of Contact at the termination of each shift.
 - Maintain spill response equipment at the IDW storage area in case it is required for immediate access.

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- Where possible, use equipment for moving containers. Where not possible, obtain help to manipulate containers.

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CAUTION

Each container of water can weigh up to 490 pounds. Each 55-gallon drum of wet soil can weigh more than 750 pounds. Fill drums and temporary containers to 80 percent capacity to minimize spill and handling difficulties. Use drum carts to move filled drums.

See safe lifting techniques provided in Section 4.4 of the Tetra Tech NUS, Inc. Health and Safety Guidance Manual.

When placing drums, keep your fingers out of pinch and smash points such as between the drums. In some cases such as well development and/or purge water, you can place the drums to be filled on the pallet and transport materials in smaller easier to handle containers.

7.4 **Decontamination Evaluation**

Upon decontamination of equipment, determine the effectiveness of the decontamination process in the following manner:

- Visual evaluation – A visual evaluation will be conducted to ensure the removal of particulate matter. This shall be done to ensure that the washing/rinsing process is working as intended.
- Instrument Screening – A properly calibrated PID/FID should be used to evaluate the presence of site contaminants and solvents used in the cleaning process. The air intake of the instrument shall be passed over the article to be evaluated. Avoid placing the instrument probe into residual waters. A PID/FID reading greater than the daily established background level requires a repeat of the decontamination process, followed by rescreening with the PID/FID. This sequence must be repeated until no instrument readings greater than the daily established background level are observed. It should be noted that the instrument scan is only viable if the contaminants are detectable within the instrument's capabilities.

NOTE

When required by project-specific planning documents, collection of rinsate blanks (see next step) shall be completed without exception unless approval to not collect these samples is obtained from the Project Manager.

- Collection of Rinsate Blanks – It is recommended that rinsate samples be collected to:
 - Evaluate the decontamination procedure representing different equipment applications (pumps versus drilling equipment) and different decontamination applications.
 - Single-use disposable equipment – The number of samples should represent different types of equipment as well as different lot numbers of single-use articles.
 - The collection and the frequency of collection of rinsate samples are as follows unless specified differently in the project-specific planning documents:
 - Per decontamination method
 - Per disposable article/batch number of disposable articles

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NOTE

It is recommended that an initial rinsate sample be collected early in the project to ensure that the decontamination process is functioning properly and to avoid using a contaminated batch of single-use articles. It is recommended that a follow-up sample be collected later during the execution of the project to ensure that those conditions do not change.

Rinsate samples collection may be driven by types of and/or levels of contaminant. Difficult to remove contaminants, oils/greases, some PAHs/PCBs, etc. may also support the collection of additional rinsates due to the obvious challenges to the decontamination process. This is a field consideration to be determined by the FOL.



TETRA TECH

STANDARD OPERATING PROCEDURES

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Applicability	Tetra Tech NUS, Inc.
---------------	----------------------

Prepared	Earth Sciences Department
----------	---------------------------

Subject DECONTAMINATION OF FIELD EQUIPMENT

Approved

Tom Johnston

Attachment A
IDW Label

INVESTIGATION DERIVED WASTE

GENERATOR INFORMATION:

SITE _____ JOB NO. _____

LOCATION _____

DATE _____

DRUM# _____

CONTENTS _____

VOLUME _____

CONTACT _____

EMERGENCY PHONE NUMBER _____

	Standard Operating Procedure	
	Site Survey	

1. Applicability

- 1.1 This Standard Operating Procedure (SOP) describes the procedure to complete a site survey.
- 1.2 This SOP does not address health and safety, decontamination, sample collection, or laboratory analysis. Refer to other SOPs, the project work plans including the quality assurance project plan, sampling plan, and health and safety plan, as appropriate.

2. Equipment/Supplies

- 2.1 Global Positioning System

3. Site Survey

- 3.1 Site survey data will be obtained using a Global Positioning System (GPS) unit with an accuracy of 0.3 meter. The backpack and hand held unit will be placed on the surveyor and the height of the antennae bottom from the ground surface will be measured. This value (meters) will be logged into the data menu for elevation correction measurements. Each measured location will be acquired by standing directly above the sample point or perimeter of the excavation. The GPS unit will connect to geostationary satellites for latitude, longitude, and elevation data collection. Precision dilution of precision error deviation will be required to be a value of less than five before collecting data. Upon satisfying this parameter, the GPS unit will collect 100 units of data for each point to obtain consistently accurate results. If the GPS unit cannot establish sufficient satellite communication due to local interference, e.g. trees or buildings, the GPS operator will step out away from the sample location in a cardinal compass direction until satellite communication is acquired and the new step-out location will be logged. The surveyor will record the sample location name and step-out direction and distance in the field notebook. The location data will be stored in the memory of the GPS unit and later downloaded.

Appendix C

Innov-X™ DELTA Premium
Environmental Specification Sheet

User Manual

Delta™ Family: Handheld XRF Analyzers

PREMIUM



STANDARD



CLASSIC



General

This Manual is solely the property of Innov-X Systems, Inc. and, along with the Delta™ XRF analyzer to which it applies, is provided for the exclusive use of Innov-X clients under contractual agreement for Innov-X test and analysis equipment and services.

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Innov-X Systems, Inc. reserves the right to make changes in the product design without reservation and without notification to its users.

Revision History

Release Date for this document and its individual sections is June, 2010. This enters the Innov-X document control system as Revision A

The material is available as Adobe PDF-type files. Distribution of the files or hard-copy representations is at the discretion of Innov-X Systems, Inc.



GO TO

See “[A7. Legal Information](#)” for information concerning Innov-X Systems, Inc.'s warranties, licenses, and liabilities.

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Delta Family End User Documentation Resources

During Delta's development and initial product shipments several End User documents have been created. They are listed in the table below.

<i>Delta Documentation Resources</i>		
<i>Innovx</i>	<i>Release</i>	
<i>Part #</i>	<i>Date</i>	<i>-----Title-----</i>
103202_RevA	July/2010	Delta User Interface Guide (UI version 2.5))
103201_RevR	June/2010	Delta Family User Manual (This document)
103076_RevA	3/2010	Delta Family Quick Start
101593_RevA	11/2007	Window Replacement: Hinged Plate HandHeld Analyzers
102922_RevA	2/2010	Delta Family User Manual (Canadian Edition)
103158_RevA	3/2010	HOW TO: Setup and Configure A-020-D Teststand/Workstation for Delta Analyzer
TBA	6/2010	HOW TO: Convert A-020-A or A-020-O Teststand/Workstation to Support a Delta Analyzer

Preface

This *Preface* provides the following information:

- “Manual Structure”
- “Document Conventions”

Manual Structure

This *User Manual* consists of eight chapters, ten appendices, this Preface, Table of Contents, and a Cover. Individual chapter material is summarized below:

C1. Introduction describes the basics of the system:

- The Innov-X Delta™ Family
- Visual tour of the instrument noting all the major components

C2. Safety Information describes general safety information:

- Priority Information
- General Precautions
- Electrical Precautions
- X-ray Safety
 - Safety Interlock Structure
 - Safe and Unsafe Usage Scenarios
 - Radiation Doses for Several Scenarios
 - Comparative Analysis of Typical Exposure
 - Common Questions and Answers
- Delta Radiation Profile
- Required Certification
- Analyzer Shut-down Procedures

C3. Safety Administration describes safety program information:

- Radiation Safety Training Recommendations
- Dosimeter badges
- A typical dosimeter monitoring program
- Dosimeter service contractors
- Registration requirements

C4. Operations describes operations and testing procedures:

- Configure and Use Delta Docking Station (DDS)
- Start-up Procedure
- Cal Check Issues
- Battery Issues
- Conducting and Ending Test Operations



NOTE

Information concerning the Delta Family's user interface is supplied in the companion document “*Delta User Interface Guide*” (PN103202_Rev2.5 June/2010). The goal is to provide revised Delta UI Guides when a substantial software change is released.

C5. Alloy Analysis Modes describes five specific modes and calibrations including:

- | | |
|--------------|----------------------------|
| — Alloy | — Pass/Fail |
| — Alloy Plus | — Precious Metal Additions |
| — FastID | |

C6. Mining Analysis Modes describes three specific modes and calibrations including:

- | | |
|-------------------|----------------|
| — Mining | — Car Catalyst |
| — Two Beam Mining | |

C7. Soil Analysis Modes describes two specific modes and two calibrations including:

- | | |
|-------------------|-----------------|
| — Soil | — Environmental |
| — Three Beam Soil | — Exploration |

- LEAP issues for Classic Delta (PIN detector)
- Check Standards
- Sample Preparation

C8. Consumer Goods Modes describes two specific modes including:

- | | |
|--------|---------------------|
| — RoHS | — Consumer Products |
|--------|---------------------|

- **RoHS Mode** provides a details from EU regulation directives which list the limits for RoHS elements and information for qualitative measurements.
- **Consumer Products Mode** is dedicated to testing for Lead (Pb)

A1. Overview: X-Ray Fluorescence (XRF) Spectrometry presents background information and general knowledge, including:

- Basic Theory and X-ray History
- Elemental Analysis
- EDXRF Spectrometers

A2. Soil Testing presents information on using the analyzer for soil analysis within certain accepted guidelines, including:

- Status for Field Portable XRF and Overview of Field Usage
- Quality Assurance
- Calibration for Innov-X Portable XRF
- Effects of Moisture on XRF Results
- Comparing XRF Results to Laboratory Results
- Common Interferences
- Sample Prep Procedures and Testing Protocols

A3. Specifications presents analyzer hardware and software specifications.

A4. Typical Delta Test Sequence

- Prerequisites noted by Mode
 - Grade Libraries
 - Check Standards
 - Sample Presentations
- Typical Test Sequence

A5. User Maintenance provides a key procedure/technique:

- Using the AC Power Adapter kit to replace a Li-ion battery
- Using the stand-alone battery charger
- Replacing a Prolene, Mylar, or Kapton Window

A6. Packing and Shipping gives the procedure for returning a unit to Innov-x.

- Warning Label for shipping products with Li-ion batteries

A7. Legal Information presents material, including:

- Analyzer Limited Warranty including:
 - Limitation of Liability
 - Warranty Period, Returns, and Repairs
 - Instructions for Contacting Innov-X
- End User Software License Agreement including:
 - Use, Restrictions, and Termination of Software
 - Liability Limitations

A8. Alloy Grade Libraries including the Alloy Factory Grade library for each Model, and a “Tramp” Library with seven base alloys.





Document Conventions

Messages

There are four messages used in this Manual:

WARNING, **CAUTION**, **NOTE**, and **GOTO**.

They are characterized by an icon and a message box topped with a colored banner. The message text is on a gray background. An example of each message is below:

	WARNING DEMANDS that you observe the actions given in the text. The WARNING message has a bold type style. <i>Remember:</i> The WARNING icon signifies information that denotes a potentially hazardous situation, which if not avoided, may result in serious injury or death.
	CAUTION SUGGESTS that you review the referenced details and heed the instructions offered. The CAUTION message has a regular type style with <i>emphasized keywords</i> .
	NOTE REQUESTS that you pay particular attention to a specified procedure or piece of information. Adds details that make it easier to use the system and this manual. The NOTE message has a regular type style.
	GO TO DIRECTS the user to another portion of this manual, or to other reference materials containing relevant data. The GOTO (or Pointer) message has a regular type style.

Type Styles

These conventions are used to present information:

Convention (Type Style)	Description
Bold	Indicates an action taken on a button or other item.
<i>Italic</i>	Menu commands, names of keys, buttons, tabs, or items from picklists. User-entered text. It is used for references to other documents, C(hapter) titles, and A(ppendix) titles (for example, "... see " C2. Safety Information "). Labels on unit's I/O panels; panel or window names of the UI (User Interface).
Courier type-face	Computer displayed text or filename.

Pagination

Page numbering in this Manual is consecutive with the Front Cover being assigned Page Number 1. This enables the PDF document file and any hard-copy print to map to the Page field information in the Adobe Reader.

C1. Introduction

C1 includes a:

- Description of the Innov-X *Delta*[™] family of handheld XRF analyzers.
- Visual tour of the instrument(s) noting all the major features, and accessories.

Description of *Delta* System

What Is It?

The *Delta* is a handheld energy dispersive X-Ray fluorescence spectrometer, generally referred to as an XRF analyzer. A complete *Delta* package consists of:

- Handheld analyzer using an integrated group of instrument components that are sealed in an ergonomically designed, light-weight body. They include --
 - Controller
 - Color touchscreen (ergonomically mounted interactive display)
 - Membrane navigation keys
 - Choice of detectors (**PiN** or **SDD**) to meet wide-ranging application goals

Coordinated with these robust characteristics, the instrument's *key feature* is Innov-X's proprietary control, data acquisition, and analysis software with customer configured options.

Additional accessories (standard and optional) include:

- Li-Ion batteries (2) - {Standard}
- Delta Docking Station (DDS) Dedicated charging and calibration unit - {Standard}
- Rugged waterproof carry case - {Standard}
- Portable test stand to create a Delta workstation (A-020-D) {Optional}
- Soil foot (A-035) (Optional)
- Soil extension pole (990055) (Optional)
- Trimble Xplorer Package (Optional)

What Does It Do?

The expanded *Delta* family of handheld XRF instruments delivers fast and precise identification and analysis for elements from magnesium to uranium (Mg to U) depending on the selected model. A weatherproof/dustproof ultra rugged design including an **integral heat sink** permits users to conduct diverse analysis testing under severe operating conditions. An added convenience feature for field use is battery **"Hot Swapping."**

Applications

The analyzer gives accurate chemical analysis for commercial or industrial areas, such as:

- | | |
|------------------------------------|-------------------------------------|
| • Positive Material Identification | • Scrap Processing |
| • Mining and Exploration | • Environmental Testing |
| • Consumer Safety | • Light Element & Aluminum Analysis |

Delta Family: Types, Models, Modes and Calibrations



Delta Types and Models

Type	Modes	Models
Premium	Alloy	DP-2000
	Environmental	DP-4000
	Mining	DP-6000
	RoHS	DP-6500
Standard	Alloy	DS-2000
	Environmental	DS-4000
	Mining	DS-6000
	RoHS	DS-6500
Classic	Alloy	DC-2000
	Environmental	DC-4000
	Mining	DC-6000
	RoHS	DC-6500

Modes and Calibrations

ALLOY Analysis	Alloy	MINING	Mining Mode	LEAD PAINT	Lead in Paint (HUD)
	Alloy Plus		2 Beam Mining		Lead in Paint (Industrial)
	FastID & Pass/Fail		Car Catalyst		
	Precious Metals				
SOIL Analysis	Environmental	CONSUMER GOODS	RoHS	THIN	Filter Analysis
	Exploration		Consumer Products		Dust Wipe

Inspection

Inspection

Use this procedure:

1. Remove the carry case from the shipping cartons; save cartons.
2. Open the carry case
Remove the shipping documentation
3. Verify that all the parts and accessories are included.
Remember that the case has **TWO FOAM LAYERS**.
4. Verify that no visible damage occurred during shipping.



WARNING

If there is damage to any of the components, DO NOT attempt to use the instrument.

Immediately contact Innov-X Customer Support at:

- United States: 1-781-938-5005
- Europe: +31 (0)73 62 72 590
- Canada: 1-778-960-6279
- Australia: 02-9577-9500

Or call your local distributor.



GO TO

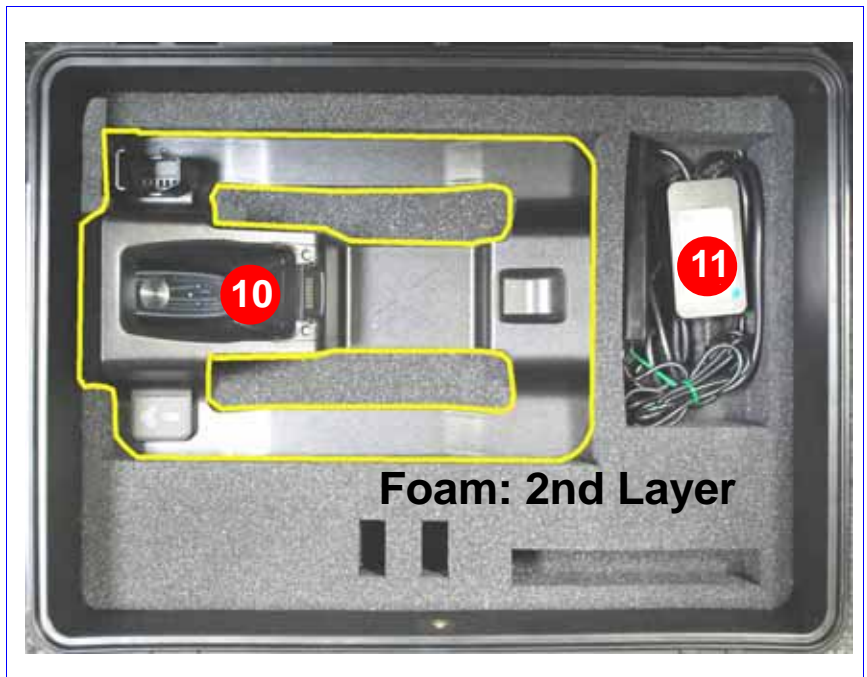
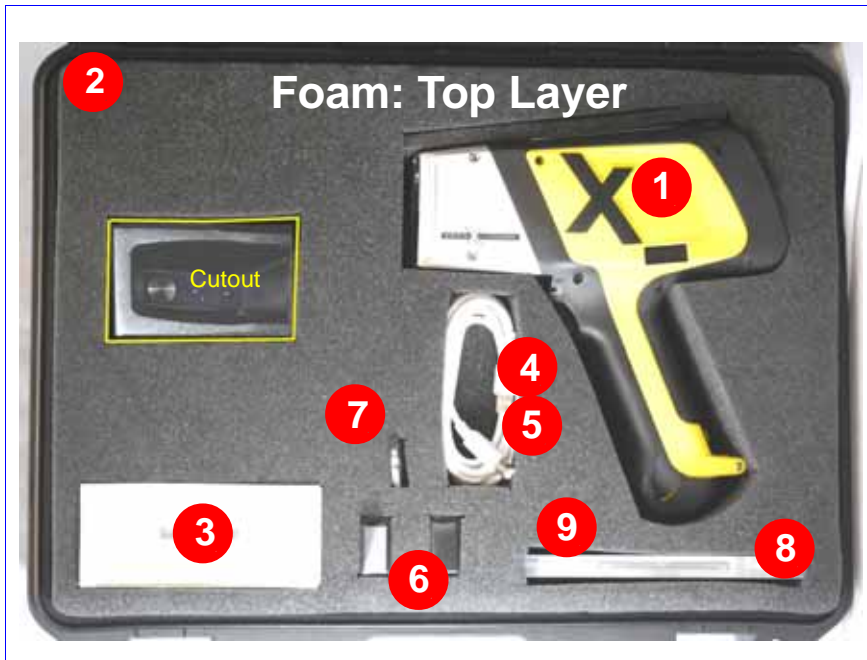
- See [C4. Operations, Page 45 & 50 Battery Issues](#) for battery charging information.
- See "[Delta User Interface Guide](#)" (PN 103202) for a complete description of the *Innov-X* application's User Interface.
- See [A7. Legal Information](#) for warranty, liability, and software licensing information.

Tour of the *Delta* Package

The figure below depicts *Delta's* major components as initially shipped to a customer. Note that the protective foam in the Carry Case has **TWO LAYERS**.

Component Key

—Foam: Top Layer—	
1	Delta Analyzer
2	Carry Case
3	Docking Station Charger
4	USB Cable #1
5	USB Cable #2
6	Li-ion Batteries (2)
7	Cal Check Coupon
8	Extra Windows (Bag of 10)
9	End/User Documentation
—Foam: 2nd Layer—	
10	Docking Station
11	AC Power Adapter (<u>Optional</u>)



Tour of Instrument

1. Handheld Analyzer

Component Key

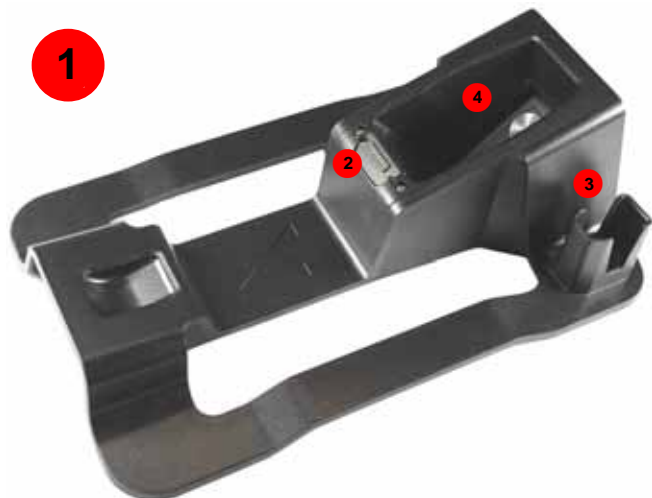
Delta - All Models

1	Delta Analyzer (Premium Model Shown)
2	Probe
3	Measurement Window (Prolene Film)
4	Hinged Window Plate
5	Docking Station Connector
6	Trigger
7	Handle - Non-Slip Rubber Grip
8	Battery Boot
9	Data Port w/ Rubber Cover
10	Heat Sink
11	I/O (Power) Switch w/ LED Indicator
12	X-ray Warning Light Array
13	Touchscreen for User Interface
14	Navigation Buttons



- 11 I/O Power Switch w/LED Indicator
- 12 X-ray Warning Light Array

2. Delta Docking Station (DDS)



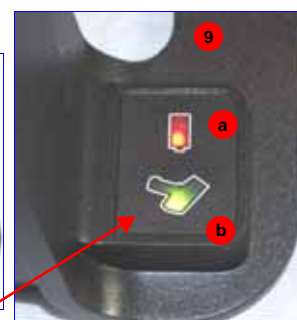
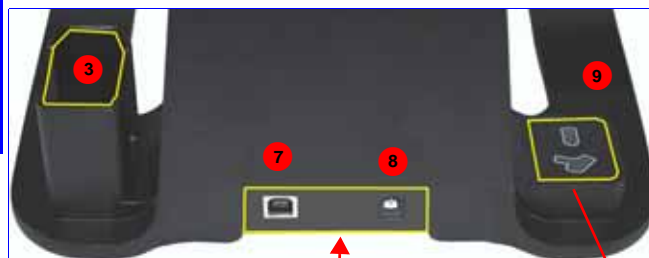
Component Key

Delta - All Model

1	Delta Docking Station (Empty)
2	Analyzer Signal/Control Connector
3	Spare Battery Charge Socket
4	CalCheck Test Cup (316 stainless steel coupon)
5	Docking Station (Loaded)
6	Second Battery in Socket
7	Data Port(s): — Docking Station ->Rear — Analyzer -> Left Side
8	Input Power (12 VDC)
9	Indicator Lights
a	Second Battery Charging
b	Analyzer Engaged



See C4/Pages 44-45
for more information



3. Accessories- List the Standard and Optional Accessories

Standard

- Batteries
- Delta Docking Station (DDS)
- DDS Power Adapter
- USB Cables 1 - USB mini to USB A
- USB Cable 2 - two part powered data cable
- Windows- Bags of Kapton and Prolene films
- Cal Check (Standardization) Coupon

Optional

- AC Power Adapter (Battery Replacement)
- A-020-D TestStand/Workstation for Delta

STANDARD Accessories

Batteries

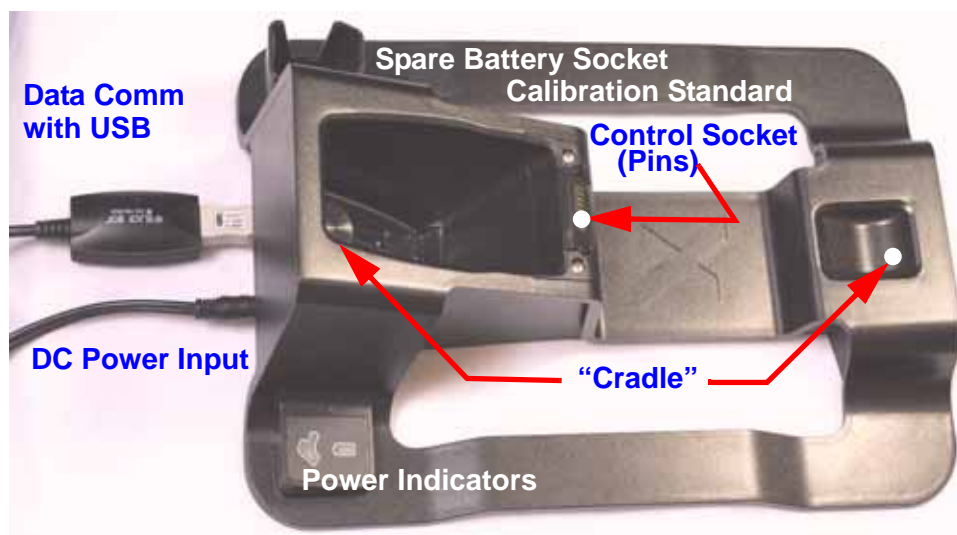
Two removable Li-ion batteries are standard accessories for the Delta.



Delta Docking Station (DDS)

This is key accessory. It provides three functions:

- Cal Check by one of two means - "On Demand" or Automatically
- Charge internal battery in handle
- Charge additional battery in auxiliary socket



See Chapter 4, Page 46
"Use DDS for Start Up & Initial Cal Check"

Power Adapter for DDS



See Chapter 4, Page 44
"Configure DDS"

I/O Cables

PN 101310: This *standard accessory* provides a means to transfer information into or out of the sealed analyzer. It is good practice to export the current day's testing results to your PC.

PN 101310
USB Data Cable
Mini USB B Connector
USB A Connector



PN 103209 and 103210: This is a two part assembly that supports communication between the Delta Docking Station and a PC.

Part One

PN 103209
USB Repeater Cable
USB A Female Connector
USB A Male Connector

Data Cable Assembly



Part Two

PN 103210
USB Adaptor
Male to Male
USB A Connector
USB B Connector

Cal Check (Standardization) Coupon

This part is used as a reference sample to provide a test standard for a Cal Check procedure if the Docking Stations is not available. The instrument indicates when a Cal_Check is necessary.



See Chapter 4, Page 51
"Cal Check Information"

Measurement Window Films

A bag of 10 window films are a standard accessory. The composition of the film is model and application dependent.

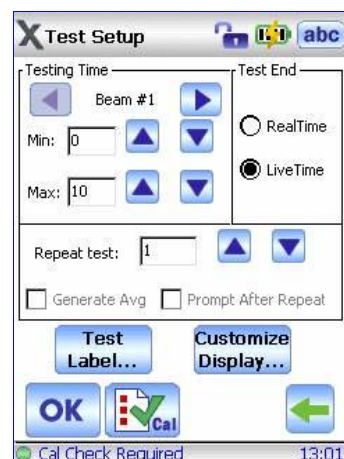
PN 103115 REV A
Kapton Windows
for Classic



PN 102999
Prolene windows for
Standard and Premium

Application Software

The *Delta* instrument is shipped with proprietary InnovX data acquisition and processing software and Windows Embedded CE® operating system. The User Interface employs an icon-based home page graphic style. Factory calibration has been completed on all purchased modes.



See the *User Interface Guide* (PN 103202) for a complete description of the Innov-X application's User Interface.

OPTIONAL Accessories

AC Power Adapter

PN 100043: This accessory enables the user to operate the instrument without the limitation of battery charge status. The unit comes with approximately ten feet of power cord that defines the effective range of use.



PC Software

This application package permits an operator to execute Innova S/W functions from a PC. With cable PN 101310, a user can connect from the Delta's mini-USB data port to a PC's USB port.



This package is optional for a handheld instrument and standard for A-020-D TestStand/Workstation. When used with the A-020-D the proper configuration cable is the powered USB assembly (PN 103209 - PN 103210)

XRF Workstation

The Delta XRF Workstation is comprised of two major components:

- A-020-D Test Stand, and
- Any Delta analyzer

In this configuration, the Delta is controlled by Innova Delta PC Software. The open-beam handheld instrument is converted to a closed-beam workstation.


See PN 103158 document: *"HowTo-Setup & Configure Delta XRF Workstation"* for complete instructions.

Tour of XRF Workstation

The **XRF Workstation** offers the following features:

- Portable, light-weight, shielded enclosure
- A rugged and repeatable testing environment
- Easily erected in laboratory or at remote field site

In this configuration the Delta (an open-beam handheld instrument) is converted to a safe closed-beam system



C2. Safety Information

C2 presents the following information:

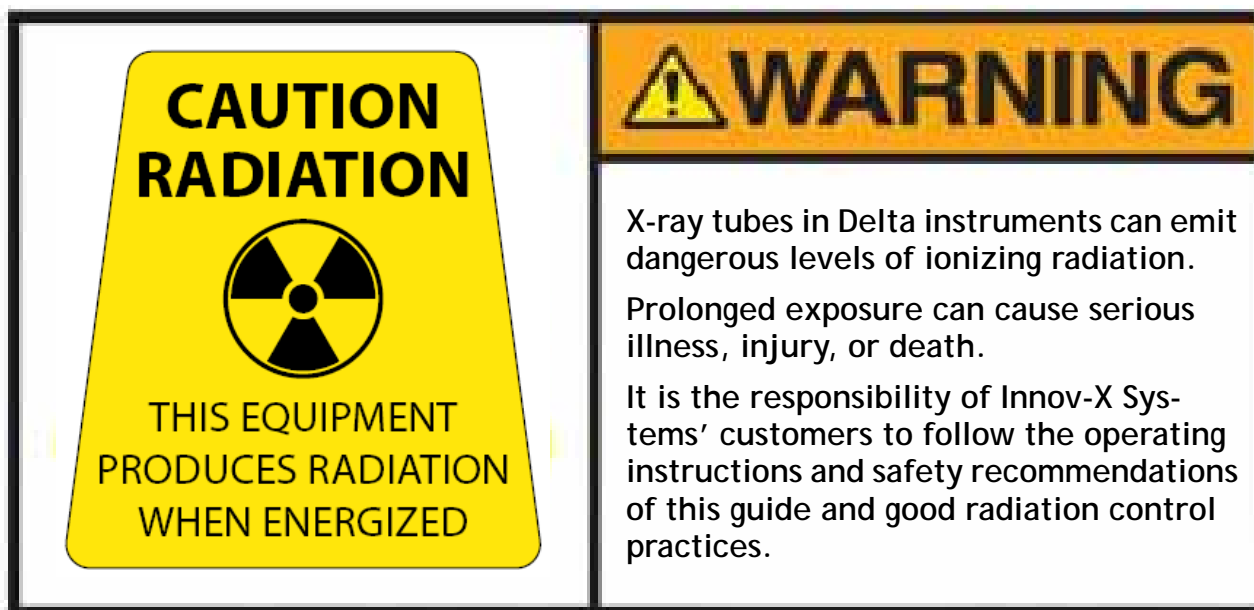
- Radiation Safety Information
- General Precautions
- Electrical Precautions
- X-Ray Safety
- Compliance
- Instrument Usage Scenarios
- Radiation Dosage for Several Scenarios
- Radiation Safety: Common Questions and Answers
- Analyzer Shut Down Procedure

Radiation Safety Information

Always make Operational Safety your HIGHEST PRIORITY.

The *Delta* Handheld XRF Analyzer is a secure and dependable instrument when used according to Innov-X's recommended testing techniques and safety procedures. However, this instrument produces ionizing radiation; only individuals trained in correct operating techniques and authorized to use X-ray producing devices should be permitted to use it. The radiation detected at any outside surface (excluding the Prolene, Mylar, or Kapton window area) is below that required for an unrestricted area.

- Heed all warning labels and messages
- Observe the safety interlock features



Radiation Safety Program


Innov-X strongly recommends that organizations using *Delta* analyzers implement a formal *Radiation Safety Program* that includes:

- Dose monitoring of critical personnel.
- Monitoring of area radiation levels.
- Information specific to the site and application of the XRF system.
- An annual review (and update, if necessary).

“C3. *Safety Administration*” provides a more comprehensive safety discussion for operators and managers.

X-Ray Safety

X-ray safety is a priority at any time and in any testing situation.

	WARNING
	<ul style="list-style-type: none"> • Innov-X analyzers must be used by trained and authorized operators, according to proper safety procedures. Improper usage may circumvent safety protections and could potentially cause harm to the user. • Heed all warning labels and messages. • DO NOT USE the instrument if there is any chance that it is damaged or might leak radiation. In such a case, arrange for qualified personnel to perform a radiation safety test and repair any analyzer damage.

General Precautions

Apply these general safety guidelines when managing or operating the *Delta* instrument:

- Retain and follow all product safety and operating instructions.
- Comply with all warnings on the product and in the operating instructions.

Comply with the precautions listed in this section to reduce the risk to:

- Users
 - Physical injury
 - Electric shock
 - Radiation exposure
- Equipment damage
 - Measurement window
 - Overheated electronics and other internal components

Service Considerations

Except as expressly noted here, do not service any Innov-X product yourself. Opening or removing the external housings may expose you to electric shock and the instrument to mechanical damage. It also voids the warranty.



CAUTION

If service is required, it must be performed by Innov-X or its authorized service representatives. Failure to observe this can result in loss of warranty. The **ONLY EXCEPTION** is replacing a damaged measurement window (see [“A5. Window Replacement”](#)).

Damage Requiring Service

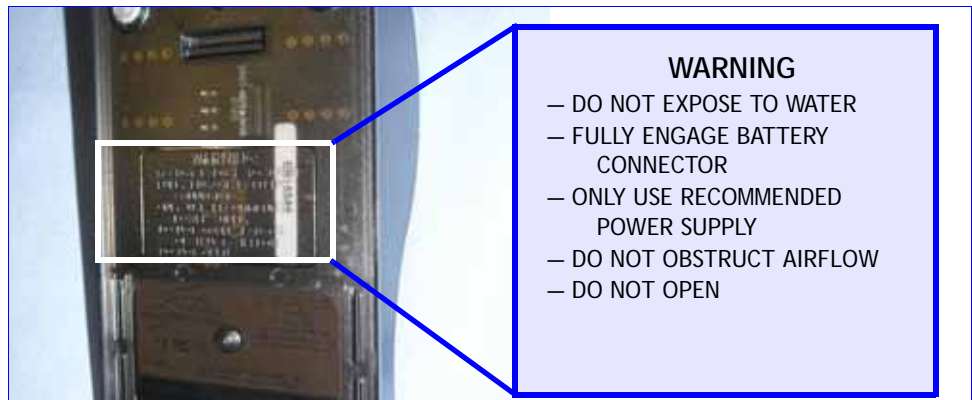
Types of problems or conditions that require service are (*but not limited to*):

- Power cords are damaged.
- Excessive or corrosive liquids spilled on the instrument or accessories.
- Instrument impacted, dropped, or physically damaged.
- Noticeable signs of overheating.
- Instrument or docking station does not perform normally when you follow the usual operating instructions.

Electrical Precautions

Guidelines for safe electrical operation of a *Delta instrument*:

- Use the correct battery or AC power adapter.
 - Install the battery or AC power adapter carefully, don't damage connections.
- Use the correct external AC power sources for the Delta Docking Station (DDS) (battery charging and Cal Checking) and the AC power adapter:
 - Ensure that the voltage is appropriate (100V-240 V/ 50-60 Hz) for operating either accessory.
 - See [“A3. Specifications”](#) for electrical specifications.
- Do not overload an electrical outlet, power strip, or convenience receptacle.
- Do not exceed 80% of the branch circuit rating.
- Comply with the warning messages on the under side of the Battery Charger.
 - Similar precautions should be observed for the Delta Docking Station (DDS).



WARNING

- DO NOT EXPOSE TO WATER
- FULLY ENGAGE BATTERY CONNECTOR
- ONLY USE RECOMMENDED POWER SUPPLY
- DO NOT OBSTRUCT AIRFLOW
- DO NOT OPEN

Cables and Cords

The *Delta* instrument and docking station is delivered with:

- AC power adapter (1) for Docking Station (standard)
- AC power adapter (2) as battery replacement for instrument (optional)

Each device has a standard IEC 3 conductor power cord which includes a safety grounding plug.

- If necessary, have an authorized individual replace these plugs to conform to local conventions.

Two data cables are supplied:

- Data cable (1) with connectors — USB A to USB B
- Data cable (2) with connectors — USB A to mini USB B

Cable Guidelines

Use these guidelines to ensure safety and proper equipment performance:

- The power cords **MUST** be connected to a properly grounded and easily accessible power outlet.
- Use a surge protector device, if possible.
- Do not defeat or bypass the ground conductor.
- Do not pull on cords or cables. Grasp the plug housing when removing the cord from the electrical outlet.
- Install all cords in accordance with applicable regulations.
- If you substitute a USB cable, ensure that the length doesn't exceed 10 feet.

Delta Docking Station (DDS) and Li ion Battery Packs

Plug the Delta Docking Station (and optional battery charger, if utilized) into a grounded electrical outlet that is easily accessible at all times.

- To handle battery packs properly do not:
 - Disassemble
 - Crush
 - Puncture
 - Short external contacts
 - Dispose of in fire or water
 - Expose to temperatures higher than 60 °C (140 °F).



GO TO

See **“C4. Battery Issues”** for instructions concerning Batteries, the Battery Charger, and the AC Power Adapter.



WARNING

**Danger of explosion if battery is incorrectly substituted.
Replace only with Innov-X specified batteries.**

**Used batteries may be returned to Innov-X Systems for disposal.
If returning batteries, or equipment with batteries installed, the shipping container must display a special caution label.
See **“A6. Packing and Shipping”** for label details.**

Indicator and Warning Lights

Power Switch w/ Integral Indicator Light

The Delta power switch is located at the upper rear of the unit.



POWER ON

- Press the I/O switch to turn on the power.
 - A green LED indicator comes on.
- This switch **DOES NOT** turn on the x-ray tube.
 - No tube power supplied until the Innov-X software is launched and a test is initiated.



POWER OFF

- Press and hold switch for >3 seconds.
 - Unit powers off. (See page 36 for more Exit options)

X-Ray Indicator Light Array

An indicator light array (six red LEDs) alerts the operator when the tube is receiving power, and when x-rays are emitted from the analyzer through the measurement window.



- When the unit is initially powered ON, the Indicator array remains Off.
- As test is conducted, array is in a **flashing** state.
- At the test's conclusion, the array stays **on continuously** until the beginning of the next test.

X-Ray Indicator ON (*Blinking*)

When the indicator array is flashing, this signifies:

- X-ray tube is powered to full operational level
- Internal filter wheel is in operational position
- Analyzer is emitting x-ray radiation through the analysis window.

In this condition, the analyzer must be pointed at a test sample.

X-Ray Indicator ON Continuously (*Not Blinking*)

When the indicator array is on continuously, this signifies:

- X-ray tube's current is set to 0.0
- X-ray tube is producing a minimum level of x-rays
- Internal filter wheel is closed so there is no radiation exposure to you or bystanders.

The instrument is *safe* to be carried or set down in this condition.

Back of Analyzer



In addition to the I/O switch and the X-Ray indicator array, the back of the Delta analyzer has:

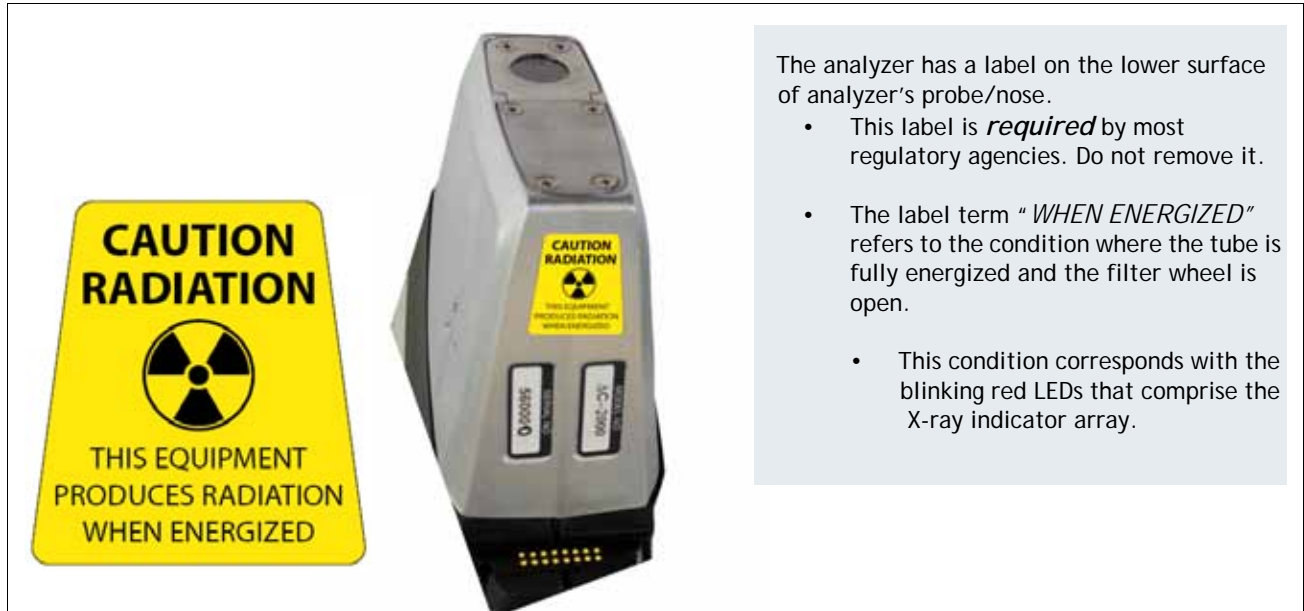
- Touch screen which displays and controls the Delta User Interface.
- Three Navigation Buttons below the screen. They permit the user to conveniently step through the Test Results Spectrum screens.



Navigation Buttons

X-Ray Label

The Delta has a warning label affixed to the lower surface of the probe.



The analyzer has a label on the lower surface of analyzer's probe/nose.

- This label is **required** by most regulatory agencies. Do not remove it.
- The label term "*WHEN ENERGIZED*" refers to the condition where the tube is fully energized and the filter wheel is open.
- This condition corresponds with the blinking red LEDs that comprise the X-ray indicator array.

Other Safety Features

Proximity Sensor

The Delta automatically detects when it is engaged with a test sample. It immediately shuts off the X-ray tube if:

(a) Initially there is no sample in front of the window,


— or —

(b) Instrument is pulled away from the sample before the test time has expired.

Safety Interlock Structure

For controlling the Delta's X-ray emissions and therefore minimizing the possibility of accidental exposure, there is a standard safety interlock structure consisting of the three features listed below.

Software Trigger Lock

- If five minutes elapse between tests (default time), the trigger locks automatically and you must tap on the lock icon  to unlock it. See Safety Software instructions in "*Delta User Interface Guide*".

Software Proximity Sensor

- Within two seconds of a test start, the analyzer detects a sample in front of the measurement window. If not, the test aborts, the filter wheel closes, and the x-rays shut off. The tube is placed in standby and the red light stops blinking.

Safeguards

As an owner of an Delta handheld XRF instrument, your safeguards are:

- Limited Access
- Trained Operators
- Shielding Issues

A. Limited Access

Keep the instrument in a controlled location, where only trained and authorized users are likely to have access.


B. Trained Operators

Keep a sign with the analyzer indicating that in order to use it an operator must have completed a training class provided by your company, or must have attended an Innov-X training course and completed any other requirements as dictated by the local regulating authority. When the Innov-X system is turned on, the controller screen displays a message indicating that the system should only be used by authorized personnel.

C. Shielding Issues

Background

The Delta emits a tightly collimated beam of X-ray radiation. The beam projects many meters when only air attenuates it.

	<p>NOTE</p> <p>Refer to governing regulations on compliance in the jurisdiction installed, dose limits, etc. Requirements differ from state to state, region to region, country to country. <i>DO NOT</i> rely solely on this manual for instruction.</p>
---	--

Action

Adequate shielding is achieved by:


- Establishing a *no-admittance zone* sufficiently distant from the instrument's measurement window that allows air to attenuate the beam.
- Enclosing the beam working area with *protective panels* (for example, 1/8" stainless steel can attenuate the beam to background levels)

Contact your Innov-X Systems representative for assistance and suggestions on interlocks and applications for limiting radiation exposure.

Instrument Usage Scenarios

The Delta is used in several testing configurations. Obey the guidelines listed below.

Practical Safety Guidelines for Handheld Analyzers

	<p>WARNING</p> <ul style="list-style-type: none"> • DO NOT POINT the unit at yourself or any other person during operation. • Never perform a test by holding the sample with your fingers or in the palm of your hand. • Always wear both a ring-style and a badge-style dosimeter.
---	--

Correct Usage

Test in Place

Test targets can include pipes, valves, large pieces of scrap metal, soil, or any sample large enough to be tested in place.

In this configuration the proper procedure is as follows:

1. Always observe the relevant parts of the *Practical Safety Guidelines* shown above.
2. Point the instrument at the sample such that *no part* of your body (including hands and/or fingers) is near the measurement window.
3. Ensure that the Delta's nose (with window) is firmly placed on the target.
4. Perform the test using one of these methods:
 - Tap Start on the UI
 - or —
 - Pull the trigger (this toggles the instrument to ON state)
 - or —
 - Pull-and-hold the trigger with the "deadman trigger" active.

Employing Steps 3 & 4 assures that no operator's body part is exposed to an excess radiation dose. The radiation detected at user interface areas is < 5 $\mu\text{Sv/h}$.

Take care that during testing, personnel are not located within three feet (one meter) of the Delta's probe head, in the direction of the x-ray beam. Provided the window is completely covered, there is minimal radiation being emitted around the area of the sample.

Small Component Testing

Examples of small component targets include metal turnings, weld rod, wires, fasteners, nuts and/or bolts.

For analysis of these types of components, use this procedure:

1. Always observe the relevant parts of the *Practical Safety Guidelines* shown above.
2. Place the sample on a flat surface.
3. Carefully place the nose/window over the sample.
4. Perform the test using one of these techniques:
 - Tap Start on the UI
 - or —
 - Pull the trigger (this toggles the instrument to ON state)
 - or —
 - Pull-and-hold the trigger with the "deadman trigger" active.

1. Sample lying on a flat surface



SAFETY PRECAUTIONS



WARNING

Do not test samples while sitting at a desk or table. If the desk is made of wood or another non-metallic material, some radiation will penetrate the desk and may provide exposure to legs or feet.

ANALYTICAL PRECAUTIONS



NOTE

If the sample does not completely cover the window, ensure that your *background surface* does not contain metals or even trace levels of metals, as this may affect the accuracy of the XRF result. The XRF may report the presence of additional metals in the surface material.

2. Clamp-held sample



NOTE

A handheld plastic locking clamp can be an effective and safe tool when analyzing small, irregular shaped samples.

Incorrect (Unsafe) Usage



WARNING

Never hold a sample in your hand such that any part of your body or appendages are exposed to the x-ray beam. Testing samples in this way may generate significant radiation exposure to your fingers.

Unsafe Testing Technique



The sample is held up to the measurement window with fingers. The sample does not completely cover the window. Even though the analyst is wearing a ring dosimeter, this is an unsafe testing technique. Here, the only value that the ring provides is to validate the level of unnecessary radiation exposure that has been experienced.

Unsafe Testing Technique



The sample is held up to the measurement window with fingers. The sample does not completely cover the window. To compound the danger, the analyst is not wearing a ring dosimeter. There is no measure of the radiation exposure endured.

Summary

InnovX repeats the Warning ---

NEVER hold a sample in your hand.

Testing samples in this way generates significant radiation exposure to your fingers.

Compliance

Complying Agency Statements

United States of America: FCC


Changes or modifications not expressly approved by Innov-X Systems, Inc. could void the user's authority to operate the equipment.

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications.

Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

Radiation Doses for Several Scenarios

In this section we provide data, concrete examples of use and misuse of the analyzer and common questions and answers we encounter when training personnel on the safe use of the Innov-X analyzer. The goal is to explain scenarios of safe versus improper usage.

	WARNING
	<p>For the x-ray energy emitted by portable XRF analyzers (8-60 keV region), the bone in the fingers will absorb radiation about 3-5 times more than soft tissue, so the bone would be at an elevated radiation risk compared to soft tissue.</p> <p>For this reason, no person shall hold a test specimen in front of the window with the fingers in the direct beam, or direct the beam at any part of the human body.</p>
	<p>Reference: <i>Health Physics</i> 66(4):463-471;1994.</p>

The table below presents radiation doses for normal operating conditions and also for examples of misuse of the analyzer and even extreme misuse. Innov-X provides installation training that includes detailed radiation safety training and documentation designed to prevent misuse of the analyzer.

Although the doses shown below are derived from experiments with TLD (thermo-luminescent dosimeters) and may or may not represent actual absorbed dose in human tissue and bone in each scenario, they are examples of the level of x-ray radiation being emitted from the device.

The message is simple:

USE CAUTION AND PROPER TECHNIQUE when operating the device.

Example: Instrument Usage	Radiation Exposure and Comments
<p>Normal Operation- Dose to Hand</p> <p>User analyzes samples according to standard operating procedures described in this manual.</p> <p>Assumption: Operator using system with x-ray tube ON for eight hours/day, five days/week, 50 weeks/year. (Alloy sample).</p>	<p>Maximum exposure is to operator's hand, at the trigger is $< 1\mu\text{Sv/h}$. Annual exposure to hand is then $< 2\text{mSv}$.</p> <p>Maximum exposure under ICRP regulations is 500 mSv for radiation workers and 50 mSv for the general public. Thus continuous operation provides a dosage 250 times lower for a radiation worker and 25 times lower for the general public.</p>
<p>Normal Operation- Dose to Torso</p> <p>Analyzer is used under the same operating conditions described above.</p>	<p>Exposure to Torso is so low it cannot be measured (essentially background). To be conservative we use 1/2 the value as the trigger, $< 0.5\mu\text{Sv/h}$. Annual exposure using operating conditions above is then estimated at less than 1 mSv. Maximum allowed is 20 mSv under ICRP for radiation workers (1 mSv for general public).</p>
<p>Misuse Example 1:</p> <p>Operator holds samples in front of window with fingers, such that fingers are directly in the primary beam. Presumption is sample does not block any radiation.</p> <p>Do not do this!</p>	<p>At the window, in the primary beam, the maximum dose to the fingers is 20,000 mSv/hr. Assume an operator performs a 10 sec. test (typical). The dose to the operator's fingers or hand is $20,000 \times (10/3600) = 55 \text{ mSv}$. If the operator did this just ten times per year he would exceed the allowable annual dose of 500 mSv to an extremity.</p> <p>Take the extra time to test a sample on a surface or use a testing stand. Note: If the operator takes a shortcut and places his/her fingers within the primary x-ray beam at the window, they will exceed the annual dose rate.</p>
<p>Misuse Example 2:</p> <p>Operator places analyzer against body and pulls the trigger to start a test. Analyzer tests to preset testing time (usually ten seconds) unless operator pulls trigger again to stop test. This applies to analyzer being in contact with operator or with bystander.</p> <p>Do not do this!</p>	<p>Dose at exit of sampling window is 20,000 mSv/h. Dose for a ten second exposure with analyzer in contact with Torso: 55 mSv. If an operator did this act just once, he would exceed the annual safe dosage to the torso of 20 mSv/year by a significant amount!</p> <p>PLEASE NOTE: The maximum dose of 20 mSv/year is a whole body limit, which does not truly apply in this case because the x-ray beam size is small (about 25 mm² area at the port). Applying correction factors for the beam size is complex and beyond the scope of this manual. The important point is that for proper operation there is no reason to ever expose any part of the human body directly to the x-ray source. This example serves to provide estimated exposure in the event this occurs.</p>

<p>Misuse Example 3:</p> <p>Operator manages to initiate a test for ten seconds running normal soil mode and exposes a bystander that is standing ten cm away from analyzer port. What is exposure to bystander?</p> <p>Note: The proximity sensor would automatically shut down the x-ray tube immediately, so this is an extremely improbable occurrence. It would require a malfunction of the instrument - this safety feature is NOT modifiable.</p> <p>Note 2: Equations to scale these to other scenarios involving longer or shorter tests, and bystander being at distances other than ten cm are provided at right.</p>	<p>Dose to bystander at ten cm is 215 mSv/hr. For a ten second exposure the dose is 0.6 mSv. This is 33 times lower than the allowable dose to a nuclear worker in a year. This would have to happen 33 times to for that worker or bystander to obtain the maximum allowable dose.</p> <p>Formula for calculating other scenarios:</p> $\text{DOSE (in mSv)} = 6T/D^2$ <p>D = distance from port in inches T = testing time</p> <p>Example: Bystander is 30 cm away from port for a 30 second test. In this case the dose is calculated as:</p> $\text{DOSE} = 6(30)/30^2 = 0.2 \text{ mSv}$
--	---

Comparative Analysis:

Radiation Doses from Typical Exposures to Ionizing Radiation

Activity	Typical Dose
Smoking	<i>2.8 mSv per year</i>
Dental x-ray	<i>100 μSv per x-ray</i>
Chest x-ray	<i>80 μSv per x-ray</i>
Drinking water	<i>50 μSv per year</i>
Cross country round-trip by air	<i>50 μSv per trip</i>
Mammogram	<i>1-2 mSv per examination</i>
Yearly exposure from background* radiation * depends on geographic location	<i>3.6 mSv</i>

Radiation Safety: Common Questions & Answers

Question: When I'm shooting a piece of pipe or valve on a rack or on a table top, is there any exposure to people standing several feet away from the analyzer?

Answer: Even a thin amount of a dense metal sample (three to four mm thickness, not Al alloy) is enough to completely attenuate the emitted x-ray beam. Shooting a piece of material that covers the sampling window on the analyzer completely shields any bystanders from radiation exposure.

However, use good practice: Keep the area clear of people for at least four to five feet in front of the analyzer.

Question: If I forget to lock the trigger, I pick up the analyzer and accidentally pull the trigger, is that dangerous to nearby personnel?

Answer: No, this example of misuse is not dangerous, but it may produce a non-negligible radiation exposure to nearby personnel. For an exposure to occur, the following things must happen.

First, you must be holding the analyzer so that a bystander is actually standing in the x-ray beam being emitted. Just being near the analyzer is totally safe otherwise.

Second, the bystander must be within one meter from the nose of the analyzer to receive any appreciable dose. If all of these conditions are true, the dose received by a bystander is still extremely low. Please see Misuse Example 3 in the table above.

Third, it would require failure of the proximity hardware and software.

Question: Do I need to create restricted areas where I am using the analyzer?

Answer: No, provided you are following normal operating procedures there is no reason to restrict access to an area where the analyzer is in use. However, the operator should take precautions to keep any personnel more than three feet away from the sampling window of the analyzer in the event of accidental misuse as detailed above. Should operators also elect to test small samples as shown on pages 34 and 35, they should also be sure that no personnel are standing within about four to five feet of the sampling window.

Question: How does the x-ray tube in the Innov-X system compare to a radiography system used for taking images of metal parts?

Answer: The x-ray tube used in the Innov-X system produces between 1,000 and 10,000 times less power than most radiography systems (0.5-1 watt versus multiple-kW). A portable XRF is designed to perform surface analysis of alloys and other samples, whereas a radiography system is designed to shoot x-rays entirely through metal components in order to obtain an image on the other side of the test object. For example, many tube-based radiography systems use a 300-400 kV tube and currents in the tens or hundreds of milliamperes (mA). The Delta uses a tube operating at a maximum of 40kV and typically 6 -10 μ A. The radiation levels produced by an Delta are thousands, or tens of thousands, times lower than a radiography unit.

Question: Should we use dosimeter badges with the Innov-X analyzer?

Answer: Dosimeter badges are required by some provincial regulatory agencies, and optional with others. Innov-X recommends that operators wear badges, at least for the first year of operation, as a general precaution to flag any misuse of the analyzer. Dosimeter badges are available for the torso (generally worn in a shirt pocket) and also as “ring” badges.

The best practice is to wear a ring badge on a finger on the opposite hand used to hold the analyzer. This records accidental exposure for the most likely case – an operator grabbing a small sample and holding it in one hand while analyzing it.

Note: These badges generally have a threshold of 100 μSv and are renewed monthly. So it takes several cases of misuse even to obtain a reading on a typical badge. When purchasing a badge, obtain the type used for x-ray and low energy gamma ray radiation.

Analyzer Shut Down

There are several techniques for shutting off the Delta. They can be categorized by whether the action is taken under normal or emergency conditions. *Shut down* or *turned off* is defined as: *The analyzer cannot provide X-ray emissions.*

Under normal conditions

Use one of following actions:

- Press the trigger.
- Tap STOP icon on the UI touchscreen.
- Navigate from **Setup** > **Exit**, then choose the Power OFF icon.



- Release the trigger if in “Deadman Trigger” mode.
- Press the I/O power switch; ensure that the On/Off LED goes off.

In an emergency

Because the Innov-X system is a battery-operated, x-ray tube-based analyzer, the Emergency Response plan is simple. If you believe that the analyzer is locked up in an *OPEN* position, the red X-ray indicator array remains illuminated or blinking:

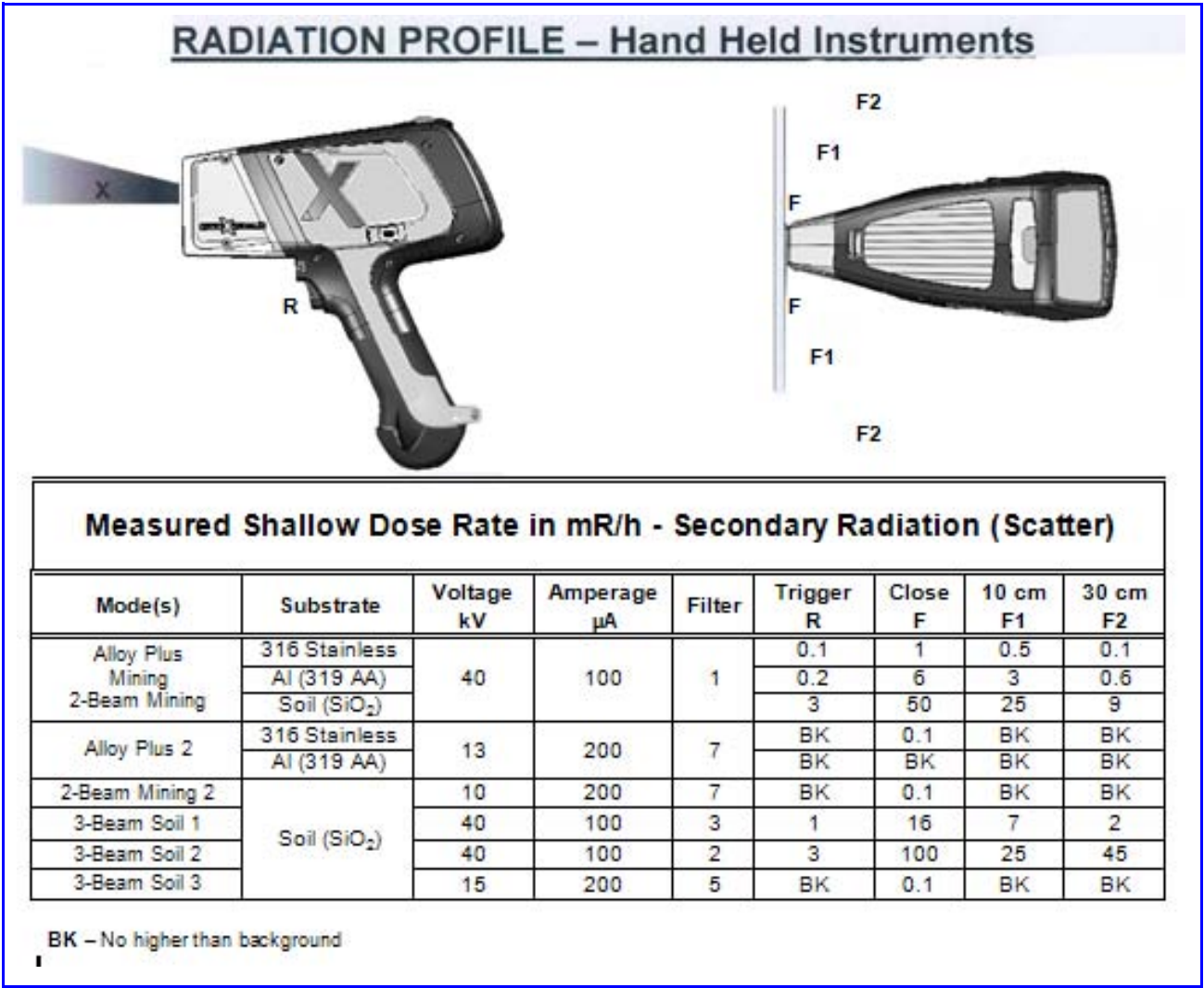
1. Press the I/O power switch as noted above. If the power does not turn off, continue to Step 2.
2. Open the battery cover and immediately remove the battery.

If you are using the AC Power Adapter:

- Remove the Battery Eliminator from the Delta’s handle
- or —
- Pull the AC cord from the AC Power Adapter or pull the plug from the receptacle.

Delta Radiation Profile

This is the current Delta Radiation Profile.



TEST CONDITION: Instrument run at normal setting for mode and represents typical production unit.

NOTES


C3. Safety Administration

C3 provides information regarding:

- Radiation safety training recommendations
- Dosimeter badges
- A typical dosimeter monitoring program
- Dosimeter service contractors
- Typical registration requirements for operating XRF equipment (in the USA)

Radiation Safety Training Recommendations

Individual companies and states have specific regulations and guidelines for using ionizing radiation generated by an X-ray tube.

	NOTES
	<p>For the convenience of clients, Innov-X has compiled a list of recommendations that:</p> <ul style="list-style-type: none"> • Provide generic guidance for an ALARA (<i>as low as reasonably achievable</i>) approach to radiation safety. • Do not replace the requirement to understand and comply with specific policies of any state or organization.

Personal Monitoring

Radiation control regulations may require implementation of a radiation monitoring program, where each instrument operator wears a film badge or TLD detector for an initial period of one year to establish a baseline exposure record. Continuing radiation monitoring after this period is recommended, but may be discontinued if accepted by radiation control regulators. See *Dosimeter Suppliers* for a list of film badges providers.

Proper Usage

Never point the instrument at a person. Never point the instrument into the air and perform a test. Never hold a sample in your hand during a test.

Establish Controlled Areas

Restrict access to the location of instrument storage and use to limit potential exposure to ionizing radiation. In use, the target should not be hand held and the area at least three paces beyond the target should be unoccupied.

Specific Controls

When not in use, store the instrument in a locked case or locked cabinet.
When in use, keep it in the direct control of a factory trained, certified operator.

Time - Distance - Shielding Policies

Operators should minimize the time around the energized instrument, maximize the distance from the instrument window, and shoot into high density materials whenever possible.

Prevent Exposure to Ionizing Radiation

All reasonable measures, including labeling, operator training and certification, and the concepts of time, distance, & shielding, should be implemented to limit radiation exposure to *as low as reasonably achievable* (ALARA).

Dosimeter Badges

A dosimeter badge consists of a radiation-sensitive material, generally an aluminum oxide crystalline layer, which is worn in a small container. It is most often attached to a person's clothing, on a belt loop, or shirt pocket. It is worn on the body in location(s) that most closely simulate the pattern of potentially absorbed dose.


The protection can also be provided in a plastic ring format. Here the detection material is lithium fluoride crystal.



These devices record a person's accumulated radiation exposure over a period of time. They monitor individuals working with, or near someone working with devices which emit ionizing radiation.

Dosimeter badges are required by some regulatory agencies, and are optional with others.

Innov-X recommends that (at a minimum) all *Delta* operators wear badges (both clip-on and ring styles) for the first year that their system is in use.

	NOTE
	<ul style="list-style-type: none"> When purchasing a badge or ring, always select the type used for <i>X-ray</i> and <i>low energy gamma</i> radiation. Innov-X suggests that the ring badge be worn on a finger of the <i>opposite hand</i> used to hold the analyzer. This records accidental exposure for the most likely case: An operator grabbing a small sample and holding it in a hand while analyzing it.

Every country (including every region, state, or province within a country) can have differing regulations. Always consult your local radiation protection authority or Innov-X Systems for information and recommendations.

Dosimeter Safety Program

A typical dosimeter-based safety program uses the following steps:

1. The company develops a dosimeter program with an independent service contractor.
 - They establish the quantity of badges needed and the frequency of analysis (a monthly or quarterly interval)
2. The company receives the first lot of badges and provides them to their analyst/operators.
3. At the end of the interval:
 - The company collects the badges and returns them to the service contractor for analysis.
 - Simultaneously, the service contractor delivers another lot.
4. The company provides the new set of badges to maintain a continuous protection /monitoring program for their employees.
5. The service contractor prepares a report for the company that tabulates any X-ray dose received and identifies any personnel with readings higher than typical background radiation.
6. The safety monitoring cycle repeats with Steps 1 through 5.



NOTE

The service contractor's written records are very important to a company's overall safety documentation plan.

Dosimeter Suppliers

Some dosimeter service companies are:

Company	Location	Telephone
AEIL	Houston, TX	713-790-9719
Global Dosimetry Solutions	Irvine, CA	800-251-3331
Landauer	Glenwood, IL	708-755-7000
• Landauer, Inc.	Oxford, England	+44-1 86-537-3008
• Nagase Landauer, Ltd.	Japan	+81-3-36 66-4300
• LCIE Landauer	Paris, France	+33-(0)1-40 95 62 90
• Landauer	Beijing, China	+86-10-62 21 56 35

Registration Requirements

Contact Innov-X for assistance with locating registration requirements information.

- Most states require some form of registration. Generally they require the registration to be received within 30 days of receipt of the system.
- Some states require no registration.
- Some states require notification in advance.

Customers are advised to consult their local radiation protection authority for specific regulatory information.

Typical Device Registration Information

The following information is usually requested by a licensing agency:

Purpose of device:

Response is *Analytical or Industrial*.

Be sure to inform the government registration office that the system will NOT be used for radiography or for medical uses.

Radiation Safety Officer:

List person who monitors training, safe use, and controls access to the system.

Authorized Users:

List the analyst/operators who have been trained and authorized by the instrument owner and/or regulating agency to operate the XRF equipment.

Operating parameters of the Delta XRF analyzer:

8– 40 kV, 5 - 200 uA max.

Type of system:

Response is: *Handheld/Portable*

User Training Specified:

Indicate that only individuals receiving manufacturer training, *documented by a manufacturer's training certificate*, will operate the system. Additional training may be required. Verify with the local regulating agencies the level and type of training required.

Personal Monitoring

Many government agency registration forms require that you indicate whether or not you intend to perform dosimeter monitoring.

See "Dosimeter Safety Program" on previous page for information regarding typical personal radiation monitoring.

CAUTION



Always keep the following documentation at the job site:

- Copy of *License Registration*
- Other pertinent *government agency* documentation
- Copies of any *dosimeter analysis* reports
- Copy of this equipment's *User Manual*.

C4. Operations

This chapter provides information regarding:

- Configure the Delta Docking Station (DDS)
- Use DDS for Initial Cal Check
- Operation - General
- Start Up Procedure
- Snapshot of Delta User Interface
- Typical Test Procedure
- Ending Test Operations
- Battery Issues
- Additional Cal Check Information
- TIPS - Things You Should Know About the Delta

Safety First !

As emphasized in *"C2.Safety Information,"* it is a priority to keep the analyzer operator's safety in mind at all times.

- Operators, *before turning on the analyzer or using the Delta Docking Station*, should review the safety procedures (*"C2.Safety Information"*).

Set Up and Use the Delta Docking Station

Background

The Delta Docking Station (DDS) provides several key functions:

- Supports an automatic or on-demand Cal_Check procedure
- Charges the "Main" battery located in the instrument's handle
- Simultaneously charges a "Spare" battery in an auxiliary socket
- Provides control information so that both batteries' status can be monitored
- Allows data communication from the Delta to a PC via a powered USB cable

The first phase for preparing to operate a Delta involves:

1. Configuring the DDS with its power and communication cables
2. Using the DDS to support the Delta's initial:
 - a. Start up sequence, and
 - b. Cal Check procedure.



NOTE

A new instrument is shipped with two fully charged Li Ion batteries. Therefore, prior to **initially** using the analyzer, it is not necessary to charge a battery.



GO TO

- See [Pages 45 and 50](#) for battery information, including charging, changing, determining status, and Hot Swap techniques.
- See [Page 51](#) for Cal Check background information.

Configure Delta Docking Station



Rear View - DDS



PN 103209 & PN 103210
Powered Hub USB Cable Assembly

Configure DDS with this procedure:

1. Plug the AC power adapter's line cord (1) into suitable AC outlet.
2. Plug the AC power adapter's DC jack (2) into the 12 Vdc socket on the rear of DDS
3. {Option at this point: Powered USB cable assembly}
 - Insert connector B (3) into DATA port
 - Insert connector A (4) into USB port of PC



Power Adapter for DDS

Use the Delta Docking Station for Charging Batteries

The Delta analyzer has a multi-purpose standard accessory: the Delta Docking Station or DDS.

In addition to providing an automatic Calibration Check, the DDS delivers two charging functions:

1. It charges the installed "Main" battery in the instrument's handle.
2. Simultaneously, it charges a spare or "Dock" battery when its inserted into the special auxiliary charging socket.

Charge status is shown in real-time on the Delta's display screen.

The second docked battery's status is also shown by the battery icon located on the rear left side of the DDS.

(either "charging = red" or "full = green")



Battery Status Screen
(Delta inserted in DDS)

Delta Docking Station Procedure for Battery Charging Functions:

1. Ensure that the DDS has DC power cable installed
See [page 44](#)
The Icon lights are Off {1}
2. With Delta Off, place instrument in cradle.
Take care that Analyzer Icon comes On (Green) {2}
The main battery in the handle is charging although there is no indicator.
3. If Delta On, the Battery Status Screen appears
4. Place a spare battery in the auxiliary socket
Battery Icon is On (Red - unless fully charged) {3}
5. Both batteries will charge; their real-time charge status is displayed.
6. When both batteries are fully charged, the Icons display Green. {4}



Cradle



Delta Docking Station Procedure for Automatic Cal_Check

1. Ensure that the DDS has DC power cable installed
See [page 44](#)
The all Icon lights are Off {1}
2. With Delta On, place instrument in cradle.
Take care that Analyzer Icon comes On (Green) {2}
Battery Status screen is displayed.
3. Ensure that the Battery Status screen stays On.

NOTE: Do not exit this screen -->> the automatic Cal_Check function will not work.



Use the Delta Docking Station for Startup - Initial Cal Check



DDS w/Empty Cradle



DDS w/Premium Delta in Cradle



1. Place analyzer into the Delta Docking Station cradle. Ensure that the Delta indicator light is ON. This signifies that the instrument is properly seated in the cradle.
2. Press analyzer's I/O switch (>1 second to turn it ON.)



DDS - Indicator Light
Delta is engaged in cradle

Radiation Safety NOTICE appears after a few seconds.

3. Read and respond to notice
Tap **START** to acknowledge that you are a certified user.
The UI begins its launch with the following messages:

Initializing System
Starting System
Loading Files

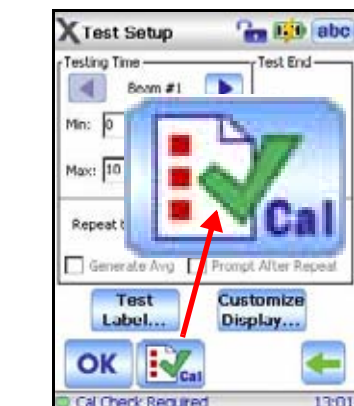
4. Unit displays a Test screen using the Mode last selected.
 - 4a. If the mode should be changed, go to **Home** screen.
 - 4b. Select the Mode button
 - 4c. Choose the desired Mode

5. Return to Test (now with your selected Mode)
Note that message *Cal Check Required* is present.

6. Choose **Tools** icon:
This launches **Test Setup** screen with **Cal_Check** button

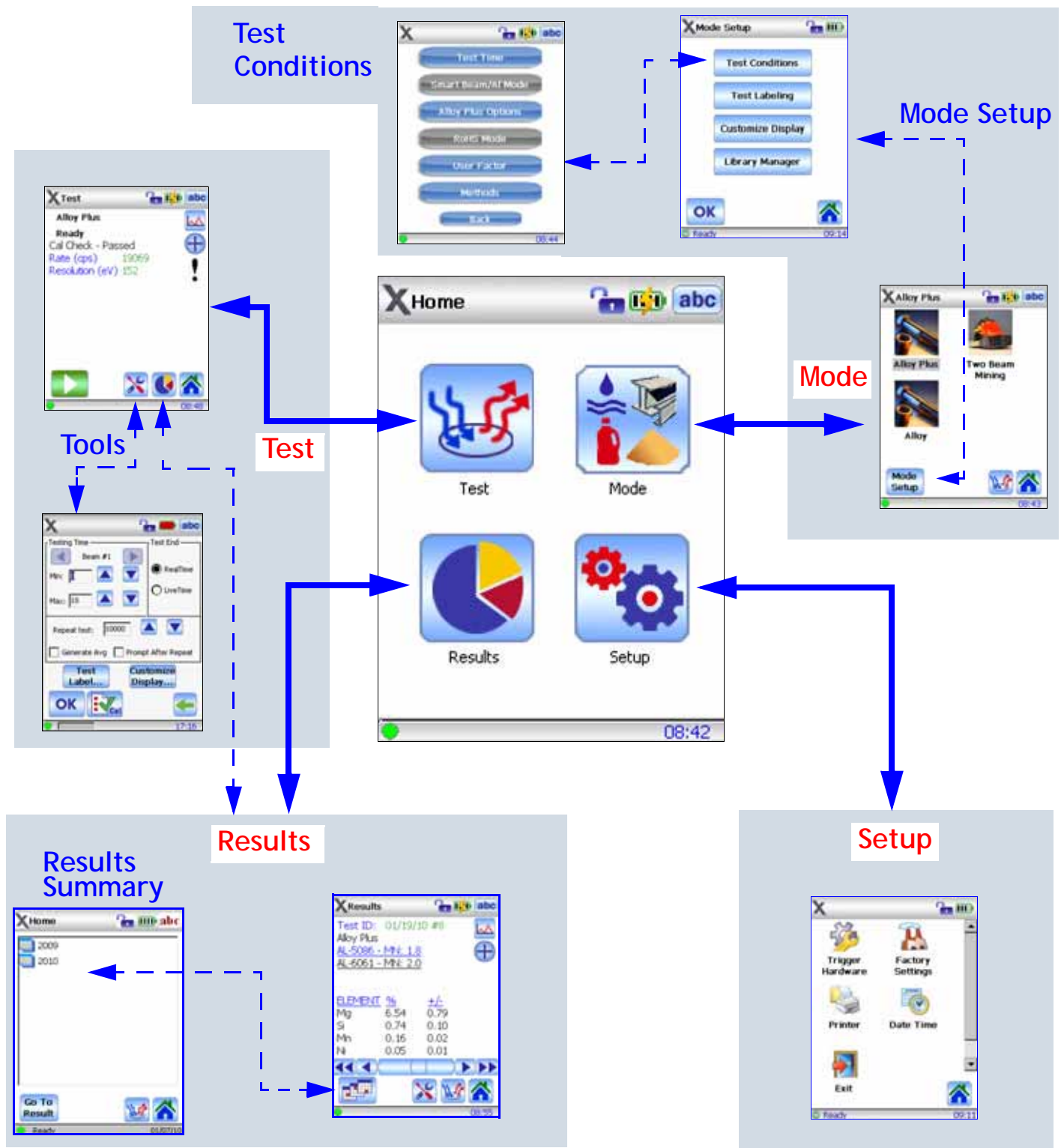
7. Tap **Cal_Check**
If necessary, unlock the **Trigger** with the icon at top of screen.
Procedure begins immediately; it concludes in about 15 seconds.

8. Message *Cal Check - Passed* means you may begin testing.
Message *Cal Check - Failed* will give error message, such as "! Wrong Count Rate"
Re-try the procedure
If unit fails repeatedly, contact InnovX service or your local distributor.



SNAPSHOT of Delta's User Interface

The Delta's user interface is introduced by the startup Radiation Safety and Initialization screens. Main operations then revolve around the Home screen.



Typical Test Procedure

Background

Details of routine testing operations vary depending on the selected analysis mode. Some relevant modes for Delta XRF users are:

<ul style="list-style-type: none"> Alloy Modes <ul style="list-style-type: none"> —Alloy Plus —Fast ID & Pass/Fail —Precious Metals 	<ul style="list-style-type: none"> Mining Modes <ul style="list-style-type: none"> —Two-Beam Mining —Mining —Car Catalyst 	<ul style="list-style-type: none"> Soil Modes <ul style="list-style-type: none"> —Environmental —Exploration 	<ul style="list-style-type: none"> Consumer Goods <ul style="list-style-type: none"> —RoHS —Consumer Products
--	--	--	---

For the test sequence (below) the instrument has:

- Mode selected (Soil 3 Beam), and
- Cal Check procedure successfully completed.

To conduct a typical test:

- Remove the instrument from the Delta Docking Station. Place the the measurement window flush against the sampling area. Ensure the sampling area is covered by the window.



WARNING

Do not point the unit at yourself or any other person during operation. Do not test small samples in your hand. Place them on a surface for testing.
See [C2, Safety Information, Pages 29-31](#) for examples of safe and unsafe testing techniques.

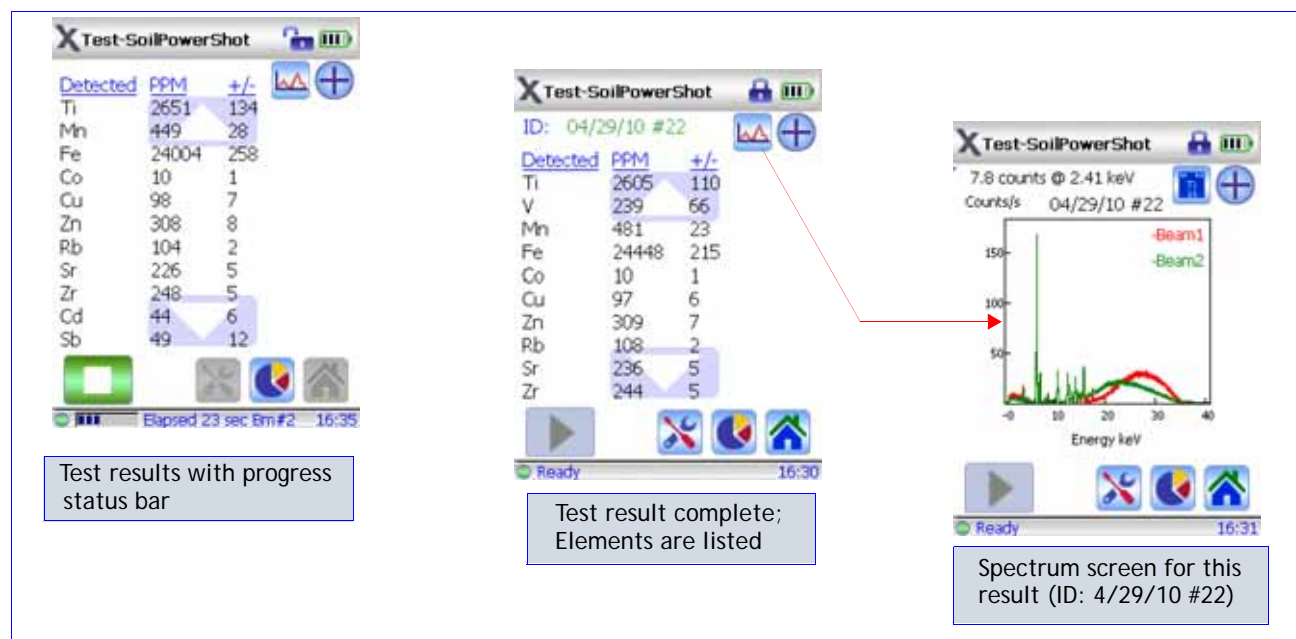
- Use one of these techniques to initiate the X-ray beam:
 - Tap Start Test (Green Arrow Icon), or
 - Pull the trigger (toggles unit ON); can release the trigger during the test, or
 - Pull-and-hold the trigger (deadman trigger function is enabled)

This is a mandatory technique in Canada.

Trigger options are configurable from:

Setup > Trigger Hardware > Trigger Settings

The Test screens are as follow:



End of Day Operations

Save Results

When finishing testing for the day (or shift, or current session) InnovX recommends that test results be saved (e.g. exported) to a PC.

A necessary prerequisite is a DATA connection between the analyzer and PC.


This connection is made in one of two ways:

- Analyzer in DDS cradle — use the powered hub USB cable assembly (PN 103209 and PN 103210) from the DDS' rear Data port to a USB port of the PC
- Analyzer NOT in DDS cradle — use the mini USB B to USB A (PN 101310) cable from the analyzer's Data port to a USB port on the PC

The UI operational sequence is:

1. Navigate from Home > Results > Calendar
2. Select Year, Month, Day listing; it lists the total number of tests for the day
3. Select Tools, then Results Setup
4. Select the Export icon (button)
5. Choose the results to be exported
6. Name the export file (or accept default name)
7. Select Destination to save to
8. Tap the Export button

The file is exported.

	<p>GO TO</p> <ul style="list-style-type: none"> • See "<i>Delta SW User Interface Guide</i>" for the details (including options) of this sequence.
---	--

Ending Test Operations

When testing and exporting are complete, the user has the following options:

- Turn off Delta with I/O switch or UI (see Exit Options procedure below); store unit in a secure location
- Place Delta in Docking Station and use the "Automatic" option:
 - Leave Delta powered ON;
 - Ensure that DDS is On (Delta ICON is lit);
 - Unit initiates Cal_Check after being idle for five minutes, then every ten hours thereafter.

Exit Option Procedure from UI

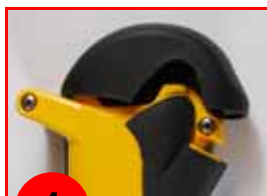


Battery Issues

1 — Changing a Battery

To CHANGE the battery:

1. Hold the instrument by the handle, upside down, so the bottom of the instrument base is pointing upward with the nose pointing away from the operator.
2. Pull the rubber latch and lift cover.
3. Remove the existing battery using the tab. A new instrument will **not** have an installed battery.
4. Insert the charged battery into the analyzer with the battery connectors facing to the left. The battery slot is keyed so that the battery can be inserted only one way.



2 — Battery Status

To TEST a Li-ion battery's charge status:

EXTERNAL battery test —

1. Push the white button on the battery.
The green lamps indicate the percent of charge, from less than 25% to 100%.
2. If a battery has a charge of less than 25%, use the Delta Docking Station to establish a full charge. See [Page 45](#).

INTERNAL MAIN battery test —

1. The battery icon from any UI screen (upper right side) shows an approximate value of charge.
2. Tap the battery icon and a more precise charge percentage is displayed as a number.



3 — HOT SWAP for Delta Battery

A battery HOT SWAP capability is a **standard feature** with the Delta analyzer. An operator can remove and replace a battery without having to shut down, restart, or Cal Check.

When the battery is removed:

- A "Shutdown" status display gives the percentage of internal charge remaining.
- If the internal charge reaches 0, you have to re-start the unit with the I/O switch, after inserting a fresh battery.
- If red X-ray indicator lights flash, the battery voltage is too low.



Cal_Check Information

Cal_Check Facts

Question: What is involved with the Cal_Check procedure?

Answer: The analyzer:

- Collects a spectrum on a known standard (Alloy 316 Stainless Steel)
- Compares a variety of parameters to values stored when the instrument was calibrated at the factory.
- When comparisons are within pre-set tolerances, the unit determines that it remains properly calibrated.

GENERAL FACTS INCLUDE:

- Cal_Check must be performed when the analyzer requests the procedure.
- The *Start* button and trigger are disabled until a successful Cal_Check is achieved.
- You can run a Cal_Check at any time during *InnovX* software operation, except during a test.
- When Cal_Check is in progress, the x-ray indicator light assembly blinks. This indicates that the X-ray tube is energized and the filter wheel is operational. In addition, a status bar appears on the UI display, showing the percentage completion for the measurement.
- The Cal_Check procedure takes about 15 seconds.

Cal_Check Procedures

There are two separate techniques:

- **In the test laboratory** - Use the DDS to initiate "on-demand" procedure. Described above in *"Use the DDS for Startup - Initial Cal Check"*:

Also have the "Automatic" option, as follows:

Leave Delta powered On and *InnovX* software running;
Ensure that DDS is On (Delta ICON is lit);
Unit initiates Cal_Check after being idle for five minutes,
then every 10 hours thereafter.



- **In the field** - Use the Coupon (the procedure is described below)

1. Place the 316 stainless steel Cal_Check coupon on a flat surface.
See *C2. Safety Information, Page 29* for safety measures that must be observed.
2. Position the analyzer's measurement window flush over the coupon.
3. With the Test Setup screen invoked, tap the Cal Check icon. There are now two techniques to choose from:
 - Tap the "Start Test" icon, or
 - Pull the trigger (or pull-and-hold if using "Deadman Trigger")
4. The procedure takes about fifteen seconds.



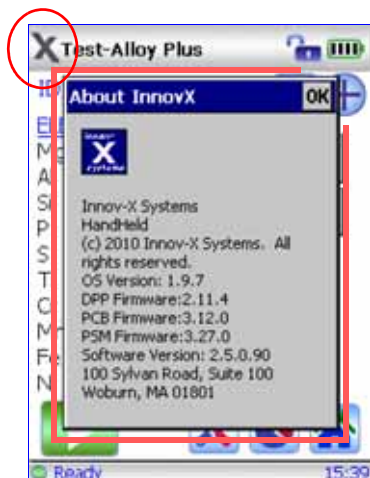
NOTE

Improperly positioning the window over the coupon can result in a failure.

5. When Cal_Check completes successfully, you may begin testing.
6. If Cal_Check fails, ensure that:
 - Coupon is positioned correctly.
 - X-ray indicator assembly is blinking during the procedure.
 - You have waited several seconds before starting the procedure.
7. If Cal_Check fails again,
 - Shut down the Delta software.
 - Shutdown and restart the analyzer.
 - Launch another attempt to Cal Check.

If Cal_Check fails repeatedly, contact Innov-X Systems Customer Service or your local distributor. Contact information is available at appendix *A6. Packing and Shipping*

TIPS - or - things you should know about the Delta



System Information

To call information "About InnovX" tap the X (InnovX icon) in upper left of UI screen. This provides various firmware and software versions that are installed on the analyzer.

UI Screen Note

All User Interface screens have a time-out (power saving) feature that causes the screen to go blank after 45 seconds if the UI is not accessed or the unit is not moved.

However, the analyzer is still running.

Restore the screen by tapping it or by moving the instrument.

Battery Status Info #1

When you turn on the instrument and you may not be aware that the battery is low, the X-ray indicator (Red LEDs) flashes dimly and briefly. The unit will not turn ON. Swap out the battery.



Battery Status Info #2

The on-screen battery icon (in upper right corner of UI) shows "real-time" battery charge status in a graphical way. Tap this icon to receive a numeric value for battery charge level.



Delta Docking Station to Delta Analyzer: Contact Status

Keep the rubber boot attached to instrument when inserting it into the DDS. This helps ensure that the DDS contact pins are engaged.

The DDS analyzer icon (rear left corner) should be ON.

If the rubber boot is not available, and the analyzer icon remains OFF, use a small piece of padding under the handle to ensure contact.

C5. Alloy Analysis Modes

Alloy analysis for the Delta family includes:

- Wide range of modes and calibrations
- Outstanding performance for a variety of materials

There are five Alloy modes/calibrations:

ALLOY

Use with: **ALL Models**



ALLOY

Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, W, Hf,
Ta, Re, Pb, Bi, Zr, Nb, Mo, Ag, Sn, Sb

Fundamental Parameters Analysis for metal alloys.

Alloy library including 300+ grade specifications, common tramp limits, including full editing capabilities.

ALLOY Plus

Use with: **Premier and Standard Only**



ALLOY PLUS

Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, W, Hf,
Ta, Re, Pb, Bi, Zr, Nb, Mo, Ag, Sn, Sb
PLUS Mg, Al, Si, P

Fundamental Parameters Analysis for metal alloys.

Optimized beam condition for extended light element performance.

Alloy library including 300+ grade specifications, common tramp limits, including full editing capabilities.

FastID

Use with: **All Models**



Spectral signature matching for alloy grade & chemistry calculation.
Full library editing & alloy matching capabilities included.

Pass/Fail

Use with: **All Models**



Spectral signature or chemistry matching for alloy grades.
Customer created library with min/max grade specifications.
Full library editing & alloy matching capabilities included.

Precious Metals Additions

Use with: **All Models**

ADDS Ir, Pt, Au, Rh, and Pd to [Analytical Analysis](#) calibration suite.

Introduction to Alloy Analysis Modes



The Delta family of instruments currently presents six unique modes for alloy analysis. The core analytical analyzer modes/types are:

- Alloy mode - Classic (PiN detector based) type
- Alloy Plus mode - Standard (SDD detector based) type
- Premium (SDD detector based) type

All three analyzer types can support additional alloy-oriented modes, such as

- FastID
- Pass/Fail
- Precious Metals (No added details)

Alloy analysis utilizes a Fundamental Parameters (FP) algorithm to determine elemental chemistry. This method calculates chemistry from the spectral data, without the requirement of stored fingerprints. The Analytical FP calibration is done at the factory, and requires no user set-up or recalibration. The software also searches an alloy grade library to produce a grade match based on the calculated chemistry. Analytical mode can provide a grade ID and chemistry in as little as one second, with increased precision for longer test times.

Alloy mode/Classic type supports Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, W, Hf, Ta, Re, Pb, Bi, Zr, Nb, Mo, Ag, Sn, Sb.

Alloy Plus mode /Standard type and Premium type supports light elements Mg, Al, Si, and P in addition to the core list of elements from the Alloy mode.

Standard and Premium units expand the Limits of Detection range permitting operators to analyze these light elements without a vacuum or helium purge requirement.

Both modes have a feature, Altitude Compensation, which automatically corrects calibrations based on barometric pressure.

Determination of Grade Identification:

Analytical modes utilize a Factory Grade Library consisting of a set of minimum and maximum values for each element in an alloy.

There is a SPECIFIC Alloy Factory Grade Library for EACH Delta model.

See appendix [A8. Alloy Grade Libraries](#) for a listing of the alloys that are contained in each Factory Grade Library.

Additionally, every analyzer is shipped with a “Tramp” library comprised of seven base alloys. These seven items with their min/max element values are increasingly valuable to fast and accurate sorting in Pass/Fail and FastID modes.

The libraries can be searched individually or together. All libraries, including each Factory Grade Library, can be edited by the user. However, InnovX strongly suggests that users NOT edit the Factory Grade Library. Instead, copy the Factory Grade Library to a USER library, then make any edits on it.

Match Number Concept

After calculating chemistry with the Fundamental Parameters algorithm, *Innov-X* compares the chemical composition values to grade tables stored in a grade library. The application calculates the value for a parameter called *Match Number*. This provides an indication of how close the measured alloy's chemistry is to library values.

- The *lower* the Match Number, the *better* the match.
- A Match Number of 0 is an *exact match*, meaning that the calculated chemistry for all elements falls within the grade table specifications.

	GO TO
	<ul style="list-style-type: none"> • See "Delta User Interface Guide" (PN 103202) for a complete description of the <i>Innov-X</i> application's User Interface. • See A8. Alloy Grade Libraries for listing of each model's "Factory Grade Library" <ul style="list-style-type: none"> • A "Spectral Fingerprint" library that would be used for "FastID" and "Pass/Fail" analysis is created by the customer.

Match Issues

There are three Match determination possibilities provided within the Analytical modes:

EXACT MATCH

An unknown alloy is matched to one of the grades contained in the Grade Libraries, and a *Grade ID* appears on the *Results* screen. Often other grades are listed with their accompanying Match Numbers. The analyst has the opportunity to view their elemental chemistries and see how they differ from an exact match.

MULTIPLE MATCHES

In some cases, several grades are shown as possible matches. This can signify one of two conditions:

- There was not enough statistical information to definitively separate two or more alloys. The actual identification of the unknown alloy is one of the grades listed. Often increasing the testing time makes it possible to separate the alloys.
- There was sufficient statistical information, but the test sample did not meet any of the existing specifications with enough precision to cause an exact match identification.

NO MATCH

If no matches are found within the libraries, the words *NO MATCH* appear.

There are several causes for a NO MATCH result:

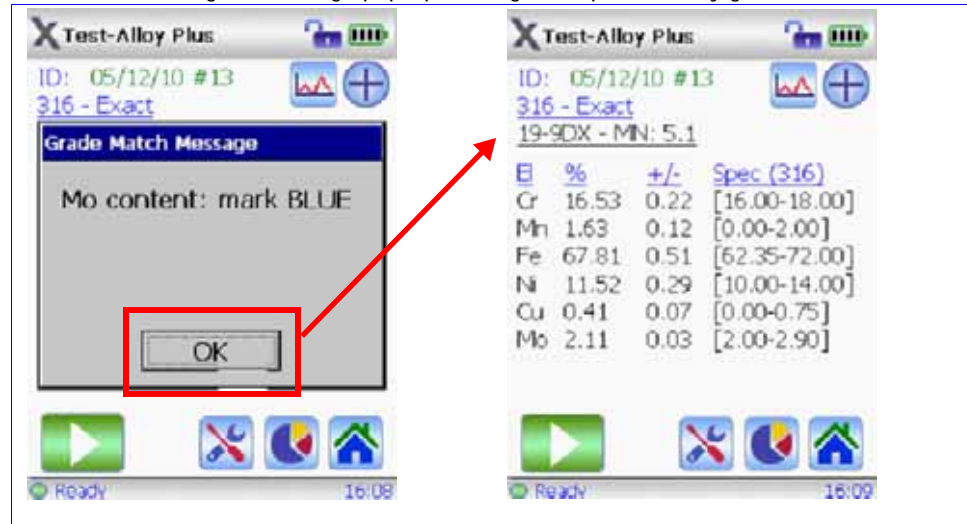
- The test sample does not meet any of the specifications in the Grade Library.
- The test sample is coated; Remove the coating by grinding, filing, or sanding and repeat the test.
- The testing time was too short.
 - Increase the testing time and measure the sample again.
- The Match Number is too low.
 - If possible, increase the Match Number

Scrap and Recycling Features

Delta analyzers in Alloy or Alloy Plus modes support many new features to specifically enhance scrap processing by maximizing speed and accuracy.

Grade Match Messaging (GMM)

User or Yard Manager can assign pop-up messages to specific alloy grades



- Quick start for next test, or view the chemistry details with one click

Grade Match Messaging offers:

- Immediate sorting instructions
- Less operator training
- More efficiency and higher throughput

SmartSort

Automated sorting decisions that allow users to maximize speed and sorting accuracy. Some features include:

- Specific grades set up to automatically extend testing time.
- Maximize efficiency for speed testing by automatically extending test time for light elements (Mg, Al, Si, P, S)
 - Eliminate unnecessary long tests

Nominal Chemistry

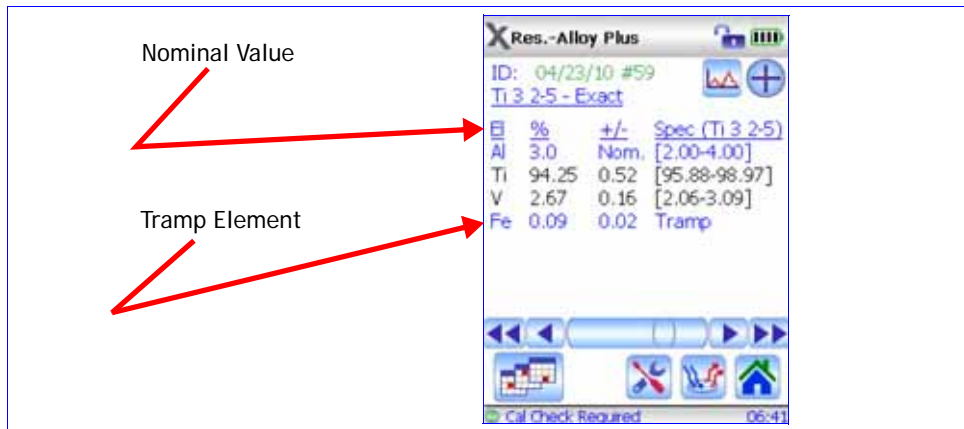
Nominal Chemistry looks for 'invisible' elements, based on grade ID, including:

- Elements not tested under active beam, (like Al in Beam 1)
- OR —
- XRF invisible elements (like B or C)

Tramp Library

Analyzers with Alloy or Alloy Plus mode come pre-loaded with a tramp library based on industry standards.

- Operators may assign other "Tramp" elements with max tolerated concentration for individual elements in seven unique graded families.
- Analyzers can report tramp material (optionally) and simplify grade match by not counting small, expected amounts of tramp elements against the grade match.



	%	+/-	Spec (Ti 3 2-5)
Al	3.0	Norm.	[2.00-4.00]
Ti	94.25	0.52	[95.88-98.97]
V	2.67	0.16	[2.06-3.09]
Fe	0.09	0.02	Tramp

See appendix [A8. Alloy Grade Libraries](#) for a discussion of the Tramp Library concept, including:

- How the InnovX Tramp Library works
- Practical advantages of the Tramp element approach
- List of seven Tramp Base Alloys

Test Sample Considerations

Coated or Painted Samples

XRF is a surface analysis technique, where X-rays penetrate a very short distance into most alloy samples. Therefore, the analyzer detects what is on the surface of an alloy, rather than what comprises the bulk of the material. If a material has been coated, plated, painted, or has had some sort of surface treatment, such as heat treating, it may be misidentified.

For example, a steel piece painted grey may show high concentrations of titanium from the paint, and may be misidentified as a titanium alloy. In another example, large amounts of metal dust or turnings on a surface may be detected by the analyzer.

To ensure proper identification of coated materials, grind an area slightly larger than the analyzing window to remove the coating. It is important to select the correct grinding material so as to not interfere with the analysis.

Do not use Silica for a Silicon analysis.

It may not be necessary to completely clean and polish all materials, however, remove obvious metal dust.

Mixed Samples, Heterogeneous Materials

Often finished metal pieces may consist of more than one type of metal. In addition, you may wish to measure mixed turnings, or an assortment of small pieces. In these cases, remember that the analyzer measures the entire area covered by the analyzing window and reports an average chemistry. For turnings, this is useful, as the analyzer provides an average composition. However, if two or more pieces of metal cover the window, the results is just an average reading, and may tell very little about the composition of one piece or the other.

When shooting metal pieces, or welds, ensure that **only** the metal of interest is covering the analyzing window.

Small and Irregularly Shaped Samples

To measure samples smaller than the analyzing window:

- Increase the testing time.
- and —
- Maximize the material in contact with the window.

The precision of analysis for small parts measurements is reduced, as the signal from smaller samples is less than for samples that completely cover the window. If possible, analyze the largest, flattest side of an irregularly shaped object.



GO TO

- See [A4. Typical Test Procedure](#) for description of a Test sequence.
- See “[Delta User Interface Guide](#)” (PN 103202) for a complete description of the *Innov-X* application’s User Interface.

Introduction to FastID Mode (All Models)



FastID mode is designed to quickly identify an alloy. It uses an empirical calibration method known as a “type” calibration. It is most useful where the number of alloys to test is small and well known.

FastID is best suited for Positive Material Identification (PMI) and QA/QC applications.

For example, where alloy producers or fabricators handle materials that may be very similar or where maximum user simplicity is a primary concern.

This mode offers:

- Simplified results (grade name only or less information on tramp elements).
- A narrow, customized grade library base upon stored spectral fingerprint reference standards.
- **Full chemical analysis based on reference standard assays.**
- Results which are the best combination of SPEED and ACCURACY.
 - A Grade and Chemistry result in as little as one to two seconds.
- User selectable match criteria settings.
- Expansion of up to 500 additional alloy grades and assays (alloy chemistries) — password protected.
- Multiple independent grade libraries. You choose to search one or more libraries.
- All libraries are editable

How FastID works:

Prerequisite: The operator creates a “custom FastID fingerprint” library by testing an array of reference standards. This list spans the number of alloys for which he is interested.

1. Delta’s XRF process allows a test sample to create a spectral fingerprint.
2. Analyzer compares this spectral fingerprint to entries from library of many certified spectra, the “custom FastID fingerprint” library.
3. Analyzer finds the best spectral match to the sample spectra: thus identifying and reporting the matching alloy grade.
4. If concentration data has been entered for the standards, the instrument then calculates the sample’s **chemistry**.

The reported chemistry data are an extrapolation from standard intensity data stored in the customer -generated fingerprint library.

The user gets a real time grade match and a precise report of the chemical composition of the sample.



NOTE

— Because FastID mode performs a spectral match to a library of reference standards, it is important that before testing, a “likely” stored reference standard be in the customer-created FastID fingerprint library.

Introduction to Pass/Fail Mode (All Models)



Pass/Fail mode is designed for high-throughput alloy sorting and quality control.

Mode Features

- All test samples are sorted by comparison to an operator-selected reference standard.
- Results are displayed as a *PASS* or a *FAIL*, depending on whether they match the reference standard.
- Pass/Fail criteria may be based on:
 - “quality of fit” to the selected spectral fingerprint
 - or —
 - elemental chemistry.
- Pass/Fail ranges may be implemented for one or more elements.
- This mode offers a full range of options from the simple sorting of mixed loads in a recycling facility to QC on specific element(s) of the most complex superalloys.

Pass/Fail mode has two options: *Fingerprint and Chemistry*.

1. Fingerprint Option

Select this method when the goal is to determine whether or not test samples are a **specific grade**.

Fingerprint Pass/Fail and FastID use the same method to determine a match.

Data from analyzed samples are compared to the reference standard fingerprint.

If the differences between the fingerprints are small enough, the sample is judged to be of the same grade as the reference sample.

This method requires:

Only that the library contains a valid fingerprint for the reference standard.

2. Chemistry Option

Select this method to determine whether the chemistries for specific elements fall **within specified min/max grade specifications**.

Chemistry pass/fail process is:

1. Analyzer uses the fingerprint method to determine whether the sample matches the reference sample.
If it does not, it automatically fails.
2. If Step 1 has a match, the alloy chemistry is calculated from assays stored for the standard fingerprint.
3. The calculated chemistry for each element is compared to the values stored in a *Grade Table*.

In order for a sample to pass, all the chemistries must be within “n” standard deviations of the min and max values specified in the grade table.

Number “n” is specified by the user.

This method requires three items:

(1) a valid fingerprint, (2) assays for that fingerprint, and (3) Min/Max values saved in the library.

C6. Mining Modes

There are three Mining modes

MINING

Use with: **ALL models**



Mining

Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, W, As, Pb,
Bi, Zr, Mo, Ag, Cd, Sn, Sb

(elements may be customized on request)

Fundamental Parameter based calibration for **ore grading and percent-level** analysis of **process bulk** samples.

Suitable for measurement of percentage level analyte concentrations, 0.5% and greater.

2 BEAM MINING

Use with: **Premier and Standard Only**



Mining

Mg, Al, Si, P, S, Cl, K, Ca,
Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, W, As, Pb,
Bi, Zr, Mo, Ag, Cd, Sn, Sb

(elements may be customized on request)

Mining mode optimized for **SDD based systems** to enhance **SPEED** and **LOD** for light elements

CAR Catalyst

Use with: **All Models**

Mode ICON
T.B.A.

Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, W, Hf,
Ta, Re, Pb, Bi, Zr, Nb, Mo, Ag, Sn, Sb

PLUS Rh, Pt, Pd

Accurate analysis of **bulk recycled catalyst** materials

The Mining modes/types are:

Mining mode - Classic (PiN detector based) type

2 Beam Mining mode - Standard (SDD detector based) type

Beam Mining mode - Premium (SDD detector based) type

Car Catalyst mode - All types

These modes utilize a Fundamental Parameters algorithm which automatically corrects for inter-element results.

The units can analyze:

- *in situ* (directly on the ground),
- prepared soil samples (in sample cups)
- bagged samples

Best Practices

Check Standards

Measure a check standard after each Cal Check, and periodically throughout the day. This confirms that data continues to be as accurate as possible.

The standards provided with Delta instruments are contained in special XRF sample cups. These cups have film windows (through which the soil can be viewed and analyzed) on one side, and solid caps on the other side.

Sample Presentation

in situ testing

In situ testing is performed by pointing the analyzer at the ground. Clear any grass or large rocks away and hold the analyzer with the probe head front flush to the ground. Since dirt can accumulate on the analyzer window, wipe the window clean after each analysis. Ensure the window is not ripped or punctured.

Bagged or prepared sample testing

Analyze prepared samples in a sample cup, through its Mylar window. Place the instrument's measurement window directly over the sample cup with the Mylar side up.

Preparation considerations include:

- Avoid measuring very thin samples, as this can affect results. Prepare samples cups to contain at least 15 mm of packed samples.
- When analyzing bagged samples, ensure that sufficient sample material exists in the bag to completely cover the window with a sample thickness of a minimum of 15 mm.
- When using bags, cheaper bags (having thinner plastic walls) are better than more expensive ones (which have thicker plastic walls).

Optional Accessories

Accessories that can assist in Mining mode testing are:

- A-035: Soil Foot
- 990055: Soil Extension Pole
- A-020-D: Workstation - portable, fully shielded, closed beam test stand for bench-top or remote controlled testing.
- Trimble Xplorer Package

Typical Test Procedure



GO TO

See ["A4. Typical Test Procedure"](#) for description of a Delta Test sequence..

Mining Mode Options

Test length in Mining Mode is user defined.

	GO TO
	Refer to <i>"Delta User Interface Guide, User Factors"</i> for procedure to modify User Factors..

Factors

Mining modes allow you to create your own set of factors, focusing on particular elements of interest or correcting for matrix effects. You can make several different *Factor* tables, allowing analysis of a variety of samples.


Setting Mining User Factors

Example:

A group of samples covering the full concentration range for each element of interest are identified. Each sample is homogenized and split. A portion of each sample is sent to an outside lab for analysis. The other portion is analyzed with the analyzer. For best results ensure that the samples are very well homogenized, and characterized, so the correlation is quite good.

Procedure:

Plot the data. Innov-X data must be on the X-axis, lab values on the y-axis.

	CAUTION
	ENSURE that you use this order: <u>Innov-X data on X-axis and lab data on the Y-axis.</u>

Determine the linear best fit with both the slope and intercept for each element. The slope and intercepts for these graphs are entered directly into the analyzer. In many cases it is sufficient to enter just a correction for the slope as the intercept is almost zero. In others, enter the slope and intercept. You can enter multiple sets of user factors for different applications, or different ore bodies. A group of factors is given a name, and then the factors are entered. The factor set can then be selected by name.

NOTES

C7. Soil Modes

The Delta family currently supports two soil modes, **Soil** and **3 Beam Soil**. Each mode has a possibility of two default element suites, **Environmental** and **Exploration**. Note that both calibration packages cannot reside on one instrument.:

SOIL Environmental

Use with: **All Models**



Soil 3 Beam

K, Ca, S, P, Cl, Ti, Cr, Mn, Fe, Ni, Cu, Zn, Hg, As, Pb, Se, Rb, Sr, Zr, Mo, Ag, Cd, Sn, Sb, Ba

(elements may be customize on request)

Compton Normalization algorithm designed for achieving lowest Limit of Detection (LOD) possible for **SOIL** and **BULK** samples. PowerShot and SmartShot 3-beam modes included.

SOIL Exploration

Use with: **All Models**



Soil 3 Beam

K, Ca, S, P, Cl, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, W, Hg, As, Pb, Bi, Se, Th, Rb, U, Sr, Zr, Mo, Ag, Cd, Sn, Sb

(elements may be customized on request)

Compton Normalization algorithm designed for achieving lowest Limit of Detection (LOD) possible for exploration samples. PowerShot and SmartShot 3-beam modes included.

Soil Mode Beam Selection

SmartShot Beam Mode:


Uses a single incident beam setting (Transition Metals) optimized to deliver ultra fast results with solid LOD performance across the periodic table. SmartShot offers excellent sensitivity in the fastest testing time possible.

PowerShot Beam Mode:


Offers a fully optimized, multi-beam analysis method that provides exceptional LODs for all elements analyzed - heavy metals, transition metals, and light elements. PowerShot can be used to analyze the full element range, or to focus in on a particular element of interest, such as Cr, Cd, Ni, or Cu. Any or all of the following beams conditions may be selected:

- Heavy Elements
- Transition Metals
- LEAP (Light Elements)


Use this procedure to configure beam selections:



From the Mode Setup screen select Test Conditions.



Select the LEAP option



Configure one or more **Powershot(s)**. Note that multiple beams may be chosen. Press Save to return to soil testing.

Best Practices

Check Standards

Measure a check standard after each standardization, and periodically throughout the day, for a minimum of one minute. Elemental concentrations for elements of interest, in the range expected at the site, plus or minus the error on the reading, should be within 20 percent of the standard value. [A2. Soil Testing](#) describes recommended quality assurance considerations in detail.

The standards provided with the analyzer are contained in XRF sample cups. These containers have a film window (through which the soil can be viewed) on one side, and a solid cap on the other side. Always measure samples through the film window.

Sample Preparation

Preparation considerations include:

- Avoid measuring very thin samples, as this can affect results. Prepare samples cups to contain at least 0.5" (usually 4-8 grams) of packed samples.
- When analyzing bagged samples, ensure that sufficient sample material exists in the bag to create a sample thickness of a minimum of 15 mm for a spot size that is larger than the analyzer's measurement window.
- When using bags, cheaper bags (having thinner plastic walls) are better than more expensive ones (which have thicker plastic walls).

C8. Consumer Goods Analysis Modes

There are two consumer goods modes:

RoHS



RoHS

RoHS regulated elements- **Cr, Hg, As, Pb, Br, Cd,**
PLUS Cl, Ti, Fe, Co, Ni, Cu, Zn, Sn, Sb, Ba

Analysis software for measurement of restricted elements in electronics and consumer goods. Auto-compensations built in for metal, polymer, and mixed matrices.

Consumer Products



Consumer

Analysis software designed for CPSIA & Prop 65 testing. **Pb** content displayed as **Pass/Fail** based on regulated limits.

Additional elements Cl, Ti, Cr, Fe, Co, Ni, Cu, Zn, Hg, As, Br, Cd, Sn, Sb, Ba also reported.

Introduction to RoHS Mode

Toxic metals in consumer electronics are the focus of EU regulations that have worldwide ramifications. These new directives currently include:

- *Restriction of Hazardous Substances (RoHS)*
 - Designates maximum allowable levels of Pb, Cd, Cr⁶⁺, Hg and certain Br-containing flame retardants (PBB and PBDE) in new electrical and electronic equipment sold into the EU.

The limits for RoHS elements are:

- <0. 1% Pb, Cr⁶⁺, Hg, Br (as flame retardants, PBB and PBDE)
- <0.01% Cd

The Innov-X analyzer is a screening tool for RoHS Compliance. It is used to:

- Directly analyze the amount of toxic metals in electronics,
- Identify quickly whether a plastic is made of or contains:
 - PVC
 - A brominated flame retardant.

XRF measures *total elemental composition*, regardless of speciation of the element.

Therefore, it reports

- Total chromium including the concentration of hexavalent chromium plus any other forms of Cr.
- Total bromine, however cannot distinguish the type of brominated flame retardant present in analyzed materials.

In order for XRF to be quantitative, samples must be:

- Homogeneous
- Have a certain minimum sample thickness
 - Five (5) mm for polymers and light alloys
 - Fifteen (15) mm for liquid samples
 - One (1) mm for other alloys

If samples are heterogeneous, too thin, or too small, only qualitative screening is possible.

The IEC-ACEA (International Electro-technical Commission – Advisory Committee on Environmental Aspects) recommends XRF screening.

Test Overview

The Delta analyzer controlled by *InnovXPC* application software (in RoHS mode) automatically executes a test sequence to determine:

- Whether a sample is an **alloy**, **polymer**, or **mixed**.
 - “Mixed” indicates heterogeneous samples consisting of both polymer and alloy, such as wires or circuit boards.
- Whether each RoHS element **passes**, **fails**, or is **inconclusive** when compared to a set of stored criteria.
 - These criteria are either those recommended by the IEC, or ones added by the user.

The sequence begins with the instrument utilizing tube settings appropriate for analyzing a polymer sample. The following logic applies:

- If the sample is determined to be a polymer or mixed, the test continues, and a calibration based on a polymer matrix is used.
- If the sample is found to be a metal alloy, the analyzer switches to a secondary test, using an alloy matrix calibration, in order to determine correct alloy concentrations.

Check Standards

Innov-X Systems recommends that a check standard be measured after each Cal Check procedure, and periodically throughout the day.

Two certified standards are provided for verification.

- At least one standard should be measured for a minimum of two minutes.
- Concentrations for target elements (plus or minus the error on the reading) should be within 20% of the standard value.
- Standards provided are contained in XRF sample cups with a Mylar window (through which the plastic pellets can be viewed) on one side, and a solid cap on the other side.
- Samples should be measured in the sample cup, through the Mylar window.

Sample Presentation

Since many pieces of plastic analyzed for ROHS compliance are very small, take care to measure them in a safe and accurate manner. See the IEC-ACEA recommendations for minimum thickness of test samples.

IEC Quantitative Screening Requirements

RoHS requirements are derived from the *“Directive 2002/95/EC of the European Parliament and of the Council of the European Union on the restriction of the use of certain hazardous substances in electrical and electronic equipment.”*

Dated 27 January 2003.

Important Current Issues



- At this User Manual's release date (May, 2010), the IEC requirements (including limits and exemptions) have **not been formally accepted**. A timetable for acceptance has not been established.
- Users must be aware that the information in Figure 1 concerning RoHS screening limits has been extracted from **proposed/draft** IEC-ACEA documentation.
- Innov-X strongly advises users to have their own compliance departments determine the **current status** of the requirements that they must meet.

Elemental Range/Limits for RoHS Compliance

—RoHS— Elements	Polymer Materials				
	PASS	Lower Limit	Inconclusive	Upper Limit	FAIL
Cd	P	$\leq(70-3s)$	$< X <$	$(130 +3s)\leq$	F
Pb	P	$\leq(700-3s)$	$< X <$	$(1300+3s)\leq$	F
Hg	P	$\leq(700-3s)$	$< X <$	$(1300+3s)\leq$	F
Br	P	$\leq(300-3s)<$	X		
Cr	P	$\leq(700-3s)<$	X		
	Metallic Materials				
	P	Lower Limit	Inconclusive	Upper Limit	FAIL
Cd	P	$\leq(70-3s)$	$< X <$	$(130 +3s)\leq$	F
Pb	P	$\leq(700-3s)$	$< X <$	$(1300+3s)\leq$	F
Hg	P	$\leq(700-3s)$	$< X <$	$(1300+3s)\leq$	F
Br			N/A		
Cr	P	$\leq(700-3s)<$	X		
	Electronics				
	P	Lower Limit	Inconclusive	Upper Limit	FAIL
Cd	P	LOD	$< X <$	$(150 +3s)\leq$	F
Pb	P	$\leq(500-3s)$	$< X <$	$(1500+3s)\leq$	F
Hg	P	$\leq(500-3s)$	$< X <$	$(1500+3s)\leq$	F
Br	P	$\leq(250-3s)<$	X		
Cr	P	$\leq(500-3s)<$	X		

Figure 1: Proposed Screening Limits for RoHS Elements

Grade Definitions for Screening

Grade	Proposed Screening Criteria
PASS	Results for ALL elements are lower than the lower limits shown in Figure 1.
FAIL	Result for ANY element higher than the higher limits shown in Figure 1.
INCONCLUSIVE	Result of the quantitative analysis, for any of the elements Hg, Pb, or Cd, is in the region defined as intermediate, OR if the result of the elements BR and Cr is higher than the higher limits shown in Figure 1, the analysis is inconclusive. Additional investigation must be performed.



GO TO

- See [A4. Typical Test Procedure](#) for description of a Test sequence.
- See “[Delta User Interface Guide](#)” (PN 103202) for a complete description of the *Innov-X* application’s User Interface.

Introduction to Consumer Products Mode

Background

This mode is dedicated to testing items for Lead (**Pb**) content.

The result output is **Pass/Fail** based on the regulated limits that are specified in:

- [CPSIA](#) (the Consumer Products Safety Improvement Act of 2008)
- [Prop 65](#) - refers to California Proposition 65 enacted in 1986

Additional elements that may be reported are:

Cl, Ti, Cr, Fe, Co, Ni, Cu, Zn, Hg, As, Br, Cd, Sn, Sb, Ba

Regulatory limits vary with the governing body, state-to-state, and country-to-country. European Union nations generally use the RoHS limits and testing practices.

The regulatory limits for Pb are:

- CSPIA: 300ppm currently, but going to 100ppm
- RoHS: see Table 1.0 on Page 70



GO TO

- See [A4. Typical Test Procedure](#) for description of a Test sequence.
- See "[Delta User Interface Guide](#)" (PN 103202) for a complete description of the *Innov-X* application's User Interface.

A1. Overview: X-Ray Fluorescence (XRF) Spectrometry

Basic Theory

Although most commonly known for diagnostic applications in the medical field, x-rays are the basis of many powerful analytical measurement techniques, including X-ray Fluorescence (XRF) Spectrometry.

XRF Spectrometry determines the elemental composition of a material. This method identifies elements in a substance and quantifies the amount present of those elements. An element is defined by its characteristic X-ray emission wavelength (λ) or energy (E). The amount of an element present is determined by measuring the intensity of its characteristic line.

All atoms have a fixed number of electrons (negatively charged particles) arranged in orbitals around their nucleus. The number of electrons in a given atom is equal to the number of protons (positively charged particles) in the nucleus. In the classical Periodic Table of Elements, the Atomic Number is specified by the number of protons. Each Atomic Number is assigned an elemental name, such as Iron (Fe), with Atomic Number 26.

XRF Spectrometry typically utilizes activity in the first three electron orbitals, the K, L, and M lines, where K is closest to the nucleus. Each electron orbital corresponds to a specific and different energy level for a given element.

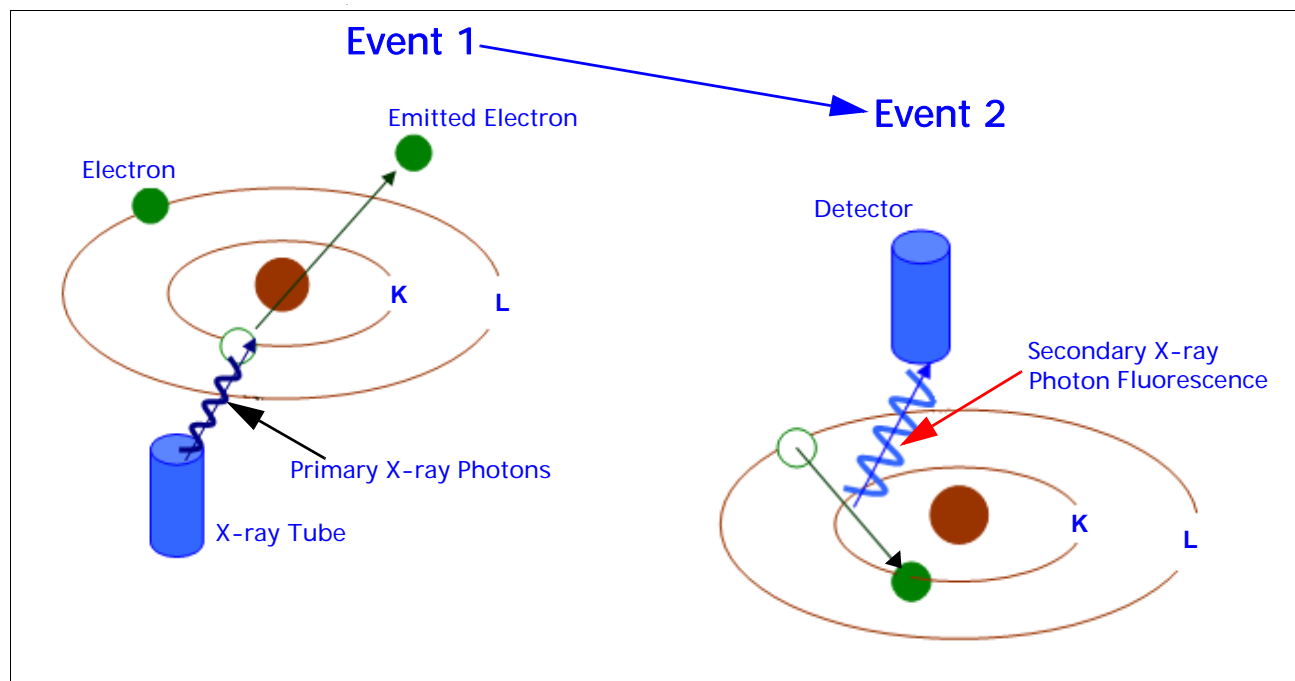
In XRF Spectrometry, high-energy primary X-ray photons are emitted from a source (X-ray tube or *radioisotope*) and strike the sample. The primary photons from the X-ray source have enough energy to knock electrons out of the innermost, K or L, orbitals. When this occurs, the atoms become unstable ions. Electrons seek stability; therefore, an electron from an outer orbital, L or M, moves into the newly vacant space at the inner orbital. As the electron from the outer orbital moves into the inner orbital space, it emits an energy known as a secondary X-ray photon.

This phenomenon is called **fluorescence**.

The secondary X-ray produced is characteristic of a specific element.

The energy (E) of the emitted fluorescent X-ray photon is determined by the difference in energies between the initial and final orbitals of the individual transitions.

This is described by the formula $E=hc/\lambda$ where h is Planck's constant; c is the velocity of light; and λ is the characteristic wavelength of the photon.

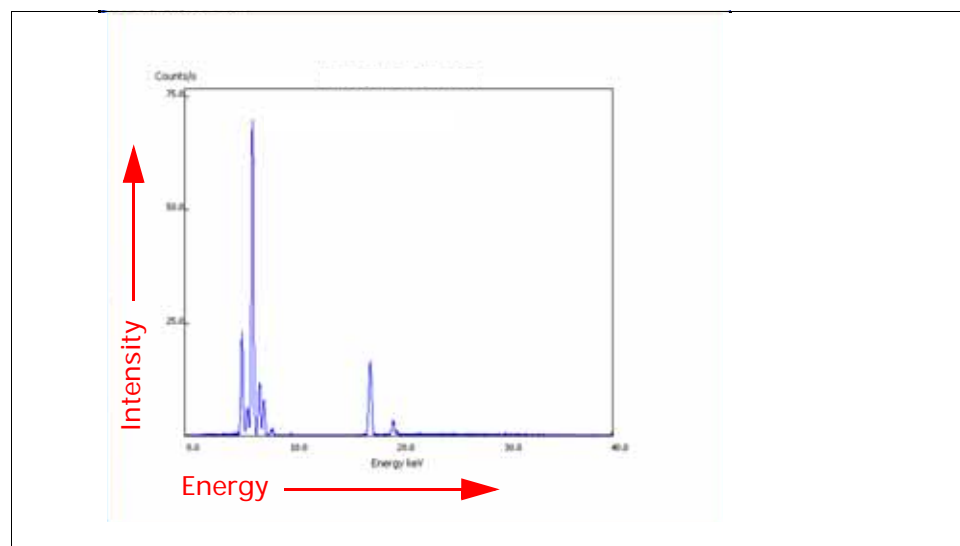


Creating a Secondary X-ray - Photon Fluorescence

Wavelengths are inversely proportional to the energies; they are characteristic for each element.

For example, the Ka energy for Iron (Fe) is about 6.4keV. The number of element-specific characteristic X-rays produced in a sample over a given period of time, or the intensity, is measured. This determines the quantity of a given element in that sample.

Typical spectra for EDXRF Spectrometry appear as a plot of Energy (E) versus the Intensity (I).



Typical Spectrum Plot: Energy vs. Intensity

History

Timeline for XRF Spectrometry

- Wilhelm Roentgen discovered X-rays in 1895.
- Henry Moseley first published methods for identifying and quantifying elements using XRF in 1913.
- XRF research and development continued, especially during WWII.
 - Critical developments in the aircraft, automotive, steel, and other metals industries increased the need to identify alloys *quickly* and *reliably*.
- The first commercial XRF Spectrometers became available in the early 1950's. These systems were based on **Wavelength Dispersive (WD) XRF** technology.
 - The characteristic **wavelength** of an element was measured **one element at a time**.
 - WDXRF systems were useful for elemental analyses, however, the equipment had the following properties:
 - Large size
 - High initial cost
 - Required highly skilled operators to use and maintain them.
- In the late 1960's, **Energy Dispersive (ED) XRF** technology emerged as a viable commercial choice:
 - EDXRF measured the characteristic **energy** of an element.
 - Improvements in solid state detectors offered better energy resolution of the signal.
 - Had potential to collect and display information on **all** of the elements in a sample at the **same time**.
- Many of the early EDXRF systems used radioisotopes for excitation. They had the following properties:
 - Required changing sources to determine all the elements of interest.
 - Did not easily resolve multiple elements in a single analytical run.
- The current state-of-the-art in EDXRF is the result of
 - Advancements in technology (particularly X-ray tubes, solid-state components, electronics, computers, software)
 - Application of the technology by instrument manufacturers, research scientists, engineers, and industrial users.
- Now a mature technology, XRF Spectrometry is routinely used for R&D, QC, production support, and regulatory compliance.

Elemental Analysis

Investigators involved with elemental analysis generally have two working instrument techniques — *Wet Chemistry* and *XRF Spectrometry*. They are compared operationally as follows.

Wet Chemistry

Important considerations are:

- Instrument techniques are *time-consuming*.
 - Often takes twenty minutes to several hours for specimen preparation and analysis.
- Specimen is *destroyed*.
- Often necessary to employ *concentrated acids* or other *hazardous materials*.
- Requires *disposal* of waste streams generated during the analytical process.
- Relatively *high cost* per sample.

However, wet chemistry instrument techniques are necessary if the primary measurement requirement involves elemental concentrations in the PPB (or lower) range

XRF Spectrometry

Important considerations are:

- Easily and quickly identifies and quantifies elements over a wide dynamic concentration range, from PPM levels up to virtually 100% by weight.
- Does *not destroy* the sample.
- Overall sample turnaround time is *fast*.
 - Requires little, if any, specimen preparation.
 - Often results are available within seconds, minutes for some details.
- Relatively *low cost* per sample

Interferences

All elemental analysis techniques experience chemical and physical interferences. They must be corrected or compensated for in order to achieve adequate analytical results.

WET CHEMISTRY ISSUES

Most suffer from interferences that are corrected only by extensive and complex specimen preparation techniques.

XRF SPECTROMETRY ISSUES

The primary interference is from other specific elements in a substance that can influence (matrix effects) the analysis of the target element(s) of interest.

However, this interference style is well known and documented.

Both types of analyzer techniques benefit from (a) instrumentation advancements, and (b) mathematical corrections in the system's software.

In certain cases, the *geometry* of the sample can effect XRF analysis.

- This is compensated for by:
 - Grinding or polishing the sample
 - Pressing a pellet
 - Making glass beads

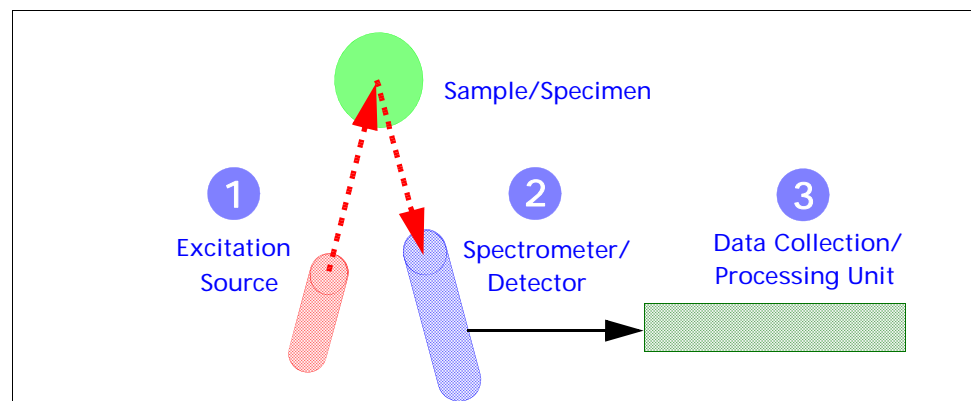
Quantitative analysis

XRF Spectrometry supporting quantitative analysis typically employs one of two software applications:

- **Empirical Methods**
Uses calibration curves derived from standards similar in property to the target unknown sample.
- **Fundamental Parameters (FP)**
FP is frequently preferred because it allows elemental analysis to be performed *without* standards or calibration curves. The analyst can use the system immediately. Modern computers support this *no-standard* mathematical analysis, FP, accompanied by stored libraries of known materials. These systems quickly determine not only the elemental composition of an unknown material, but even identify the unknown material itself.

EDXRF Spectrometers

An EDXRF instrument typically has three major subsystems:



Three Subsystems of EDXRF Analyzer

EDXRF analyzers are mechanically very simple; there are *no moving parts* in the excitation and detection subsystems. However, a bench-top analyzer can have moving parts.

When compared to WDXRF systems, EDXRF systems exhibit the following attributes:

- Ease of use
- Rapid analysis time
- Lower initial purchase price
- Substantially lower long-term maintenance costs

EDXRF analysis equipment is useful for many applications, including:

- Environmental analysis
- RoHS/WEEE compliance
- Scrap alloy sorting
- Forensic science
- Archaeometry

NOTES

A2. Soil Testing

This appendix explains usage of all of the company's hand-held portable analyzers with the *Soil* or *3 Beam Soil* mode option installed.

This document offers instructions/procedures and regulations, as well as useful reference material, regarding:

- Portable XRF equipment usage in accordance with accepted methods.
- Basic overview of the technique of x-ray fluorescence (XRF).
- Appropriate data quality assurance protocols.
- Sample preparation steps for operators analyzing prepared soil samples.
- Tables of certified values for selected standards.

If LEAP mode is enabled, refer to configuration help in [PN 103202](#).

Section 1: Commonly Accepted Methods for Field Portable XRF

A commonly accepted method is shown: *Field Portable XRF Spectrometry for the Determination of Elemental Concentrations in Soil and Sediment*.

Features of this method are:

- It is a field screening method, for analysis of *in-situ* or bagged samples.
- The method provides basic quality assurance methods, including calibration verification, determination of instrument precision, accuracy and limit of detection.
- The method recognizes that some XRF instruments do not require site-specific calibrations by the operator, that is, the factory calibration provides appropriate data quality.
- The method recommends that a minimum of 5-10% of samples tested by XRF be confirmed by an outside laboratory, using a total-digestion EPA analytical reference method.

The purpose of this method is **NOT** to replace laboratory analysis.

There are two primary sources of error in assessing a site for metal concentration: *Analytical error* and *Sampling error*.

ANALYTICAL ERROR

The error in the analysis of any one sample by whatever technique is used, for example XRF, ICP, or AA.

SAMPLING ERROR

This arises when **too few** samples are collected and tested.

In this case an incomplete picture of the extent of metals contamination may be obtained. Although any one sample may be analyzed with very high analytical accuracy, measuring too few samples may result in contamination plumes being mis-judged in size, or depth into the soil. In extreme cases contamination can be missed entirely.

Methods have been developed to reduce Sampling Errors by **increasing** the number of samples measured. In general, a large number of screening-level measurements provide a better characterization of contamination than a small number of measurements produced by sample removal and analytical analysis. A large number of in-situ samples provide detailed data on contamination profiles, depth (provided surface soil is moved aside), and approximate contamination levels. Portable XRF can provide results with a high degree of analytical accuracy on any given sample.

Section 2: Overview of Field Usage:

Field portable XRF is generally used in three ways to test for metals in soil:

IN-SITU SOIL TESTING:

The XRF is placed directly onto the ground for soil testing. Operators remove any plant growth and foreign objects so that the analyzer probe is flush to the soil.

BAGGED SOIL SAMPLE TESTING:

A soil sample is collected in a thin plastic bag (i.e. a *Baggie*) and testing occurs directly through the Baggie. Except for a few elements - namely Cr, V and Ba - testing through the thin plastic bag has little effect on the test result. However, results for Cr, V and Ba will be lower by 20-30%.

PREPARED SOIL SAMPLE TESTING:

Prepared sample testing assures the operator of the maximum possible accuracy. Prepared sample tests require a sample to be collected, dried if necessary, sieved and ground into a powder. The prepared sample is then placed into a baggie or XRF cup for analysis.

Sample prep procedures are provided on Section 8: Sample Prep Procedures and Testing Protocols on page 130.

ALL analytical methods require a *uniform, homogenous* sample for the best results. XRF is no different!

The methods generally used, namely In-situ and bagged sample testing, are considered *field-screening methods*. Although a field-screening method, in-situ testing is a valuable technique because it generates a great deal of data very quickly. Prepared soil samples generally offer the best accuracy, albeit with several minutes of sample preparation required per sample.

Subsection 2-A: Data Quality Objectives

The objective of testing is generally to determine the mixture of in-situ versus prepared sample testing. It is important to understand your data quality objectives (DQO) in order to determine the appropriate mix of field screening and prepared sample testing.

In-situ testing usually provides only *screening-level data quality*.

This is because analytical testing always requires a uniform, homogeneous sample matrix. A laboratory achieves this by digesting the sample into a hot acid before analysis. Testing directly on the ground does not ensure that uniformity is met.

Preparing a sample provides a uniform sample and likely better analytical data quality, although several minutes of testing time is required.

Most portable XRF operators use a mixture of in-situ and prepared sample testing. The exact mixture of in-situ and prepared sample testing depends upon the goals of the soil testing. The examples below serve as guidelines.

Example 1: Initial site investigation to provide detailed contamination data with efficient use of laboratory analysis costs.

PROBLEM:

The site needs to be assessed for metals contamination. Little information is available about what metals are present, likely contamination levels or geographic profile of contamination.

The goal of testing is to determine what metals are present at what levels, both in area and in depth into soil. Additionally, testing will locate possible contamination plumes and/or possible sources of contamination.

RECOMMENDED TESTING PLAN:

This example uses predominately in-situ testing. The analyst will perform in-situ testing, and gather samples into plastic bags for XRF analysis. A testing grid should be established in two or three dimensions, every several feet. XRF tests can be taken at each location or bagged samples can be collected from each location for later analysis. The in-situ data for each element analyzed may be plotted in a 2-dimensional grid (X, Y coordinates versus elemental concentration) to profile a site. These concentration profiles are ideal for showing contamination patterns, boundaries and plumes. Combining this data with historical use data from the site often allows the operator to deduce sources of contamination. Obtaining this level of geographic data with purely laboratory analysis would produce excessive analytical costs.

Prepared sample analysis should also be done to confirm the regions where in-situ data indicates low or non-detected levels of metal contaminant. There is little need to prepare areas where in-situ testing indicates high concentration levels.

Innov-X recommends this procedure:

For locations where in-situ tests indicate low or non-detected concentrations, calculate the total number of in-situ tests, collect 5% of this number of tests from the various locations. Prepare these samples according to instructions on "Section 8: Sample Prep Procedures and Testing Protocols on page 130." Use these prepared samples to confirm the findings of the in-situ testing. Send a subset of these prepared samples to a laboratory for confirmatory results.

COST JUSTIFICATION:

To adequately characterize a site may require 100-200 samples/acre to be sure the contaminated areas are firmly established. This work may be done with in-situ testing to generate laboratory savings of \$5,000 - \$10,000/acre depending upon the number of elements being analyzed. The cost reduction in off-site analysis often justifies the price of the XRF.

Example 2: Monitor remediation efforts and assure site meets clearance levels before contractors leave the site.

GOAL:

Minimize remediation costs by only treating contaminated soil, and obtain immediate verification that various site locations meet clearance objectives.

RECOMMENDED TESTING PLAN:

This type of project uses a lot of both in-situ and prepared sample testing. Use in-situ testing to thoroughly delineate contamination regions in both area and depth. To determine depth profiles, test surface soil, remove at least 1-2', and retest. Repeat this step as necessary to profile contamination depth to guide remediation activities (XRF is a surface technique and only analyzes the first few mm of soil sample). As part of clearance, collect several samples from *cleared* area. Prepare samples according to "[Section 8: Sample Prep Procedures and Testing Protocols](#)" on page 92. Test with portable XRF.

If XRF indicates that concentration levels are:

- In excess of clearance requirements, then continue remediation efforts.
- Below clearance requirements, then discontinue remediation efforts, and send a subset of the samples to an analytical laboratory to confirm results. Most operators safely assume that the cleanup requirements have been met for the elements in question, but await final analysis from the laboratory.

If XRF lists concentration levels as non-detected, but the detection level reported exceeds clearance requirements, send samples to a laboratory for final results.

Cost Justification: In-situ results are used to guide remediation efforts, in order to obtain maximum efficiency. Efficiency is produced because contamination boundaries are firmly established, thus avoiding remediation efforts with *clean* soil. Prepared sample testing is used to assure that clearance requirements are met on-site in near real-time (pending laboratory confirmation). Costs savings are generated by avoiding clearance failures. The contractors can leave the site earlier and will not be called back to the site for additional cleanup.

IMPORTANT NOTE:

Never clear a site based solely on in-situ testing. Always use well-prepared samples to make a clearance decision.

Example 3: Minimize volume of hazardous waste for treatment or disposal.

GOAL:

For some cleanup projects, the cost of soil disposal in a hazardous waste landfill is much greater than disposal in a standard landfill. Testing soil samples with XRF may minimize the amount of *clean* soil that is inadvertently shipped to a hazardous-waste landfill.

RECOMMENDED TESTING PLAN:

This example is almost entirely based on prepared sample testing. Representative samples are removed from the soil being hauled to landfill. Obtaining an accurate analysis of the samples is crucial for making a hazardous versus non-hazardous determination. For this reason, prepared sample testing is strongly recommended.

IMPORTANT NOTE:

These types of samples are subject to Toxicity Characteristic Leaching Procedures (TCLP) for the landfill determination. In general, 20 times the XRF result should be less than the allowable limit for the metal in question. Please contact Innov-X Systems for more details on testing samples versus TCLP regulatory requirements.

Section 3: Quality Assurance

Quality assurance is detailed for both the proper use of the analyzer and for verifying the data quality of in-situ testing. All operators should perform the QC procedure, regardless of their data quality objectives. There must be strict requirements about quality assurance. Additionally, Innov-X recommends that operators verify the data quality of in-situ test results, if they are using in-situ data to guide their reporting or remediation decisions. Procedures are listed below:

Proper verification of instrument operation

Quality assurance here consists of testing known standards to verify calibration, as well as testing blank standards to determine limits of detection and to check for sample cross-contamination or instrument contamination. We recommend a detailed procedure, which is provided here in abbreviated form.

Components of instrument QC:

- An energy calibration check sample at least twice daily
- An instrument blank for every 20 environmental samples
- A method blank for every 20 *prepared* samples
- A calibration verification check sample for every 20 samples
- A precision sample at least one per day
- A confirmatory sample for every 10 environmental samples

Energy Calibration Check: The Innov-X analyzer performs this automatically; this is the purpose of the standardization check when the analyzer is started. The software does not allow the analyzer to be used if the standardization is not completed.

Instrument Blank: The operator should use the SiO₂ (silicon dioxide) blank provided with the analyzer. The purpose of this test is to verify there is no contamination on the analyzer window or other component that is *seen* by the x-rays. We recommend an instrument blank at least once per day, preferably every 20 samples. For either in-situ or prepared-sample testing, the operator should just test the SiO₂ blank to be sure there are no reported contaminant metals.

Method Blank: The purpose of the method blank is to verify that cross-contamination is not introduced into samples during sample preparation. We recommend following the sample preparation procedures with clean SiO₂ once every 20 prepared samples. This QC step is not required if the operator is not preparing samples.

Calibration Verification: Innov-X provides standard reference samples for calibration check by operator. The operator should perform a two minute test on a standard. The difference between the XRF result for an element and the value of the standard should be 20% or less. Calibration Verification should be performed upon instrument startup and periodically during testing.



NOTE

Innov-X recommends a calibration check every 4 hours. Some users make a calibration check every 20 samples. Reference standards are generally applicable for Pb, As, Cr, Cu, Zn. Innov-X provides additional reference standards for Priority Pollutant metals including Cd, Se, Ag, Hg, Ag, Ba, Sn, Sb, and Ni.

Precision Verification: It is good practice to make a minimum of one precision sample run per day by conducting from 7 to 10 replicate measurements of the sample. The precision is assessed by calculating a relative standard deviation (RSD) of the replicate measurements for the analyte. The RSD values should be less than 20 percent for most analytes, except chromium, for which the value should be less than 30 percent.

Confirmatory Sample: It is recommended that one confirmatory sample is run for every 10 samples collected. It is good practice to have confirmatory samples collected from the same sample material that is analyzed on site, but are sent to an off-site laboratory for formal analysis. The purpose of a confirmatory sample is to judge the accuracy of the data obtained by analysis on site and to allow corrections, if necessary."

Important Notes about confirmatory samples:

Innov-X always recommends that customers compare prepared-sample results to laboratory results. To do this, collect and prepare a sample following the protocols shown on "[Section 8: Sample Prep Procedures and Testing Protocols](#)" on page 92. Take a subsample and submit to the laboratory for analysis. The single largest error in XRF analysis is lack of sample preparation. For the best comparison, always use prepared samples.

Determining data quality of in-situ testing:

For operators relying extensively on in-situ testing, it is important to determine the data quality of this testing at a given site. *This protocol is not intended for every sample, but rather for a small percentage of samples considered representative of the site.* If the operator can demonstrate that quantitative data is achieved with little or no sample preparation, then the site characterization will be completed much more quickly but correctly.

For example, an operator may be able to demonstrate that the XRF result changes considerably when samples are passed through a 2 mm sieve, but that XRF results do NOT change appreciably upon finer sieving. In this case, the operator can conclude that good XRF data is achievable with only 2 mm sieving. Sieving only to this level requires far less time than a more robust sample preparation.

A protocol to determine the *appropriate level of sample preparation* is the following:

1. Delineate a region of soil approximately 4" x 4".
2. Perform several in-situ tests in this area, or collect the top (approximately) quarter inch of soil from this region, bag the soil, test through the bag. In either case, average the results.
3. If you did not bag the in-situ test sample, collect the top (approximately) quarter inch of soil from this region and sieve through the 2 mm sieve provided. Otherwise sieve the bagged sample used for the in-situ test. Thoroughly mix the sieved sample, and place some of the sieved material into an XRF cup, and perform a test of this sample.
4. If the results of this prepared sample differ by:
 - Less than 20% with the average in-situ result, this indicates the soil in this region is reasonably homogeneous. The data quality in this case is probably at the semi-quantitative level, rather than just screening data.
 - More than 20%, this indicates the soil is not very homogeneous, and there are serious particle size effects affecting your in-situ measurements.
In this case, sieve the sample through the ~250 μ m sieve. Mix this sample and place a sub-sample into an XRF cup for testing. If this result differs from the previous by less than 20% then this indicates that at a minimum the 2 mm sieving is necessary to achieve higher data quality.
If this result differs by more than 20% from the sample sieved through 2 mm, then particle size effects are still affecting the XRF result. In this case samples should be sieved through 125 μ m to assure data quality at the quantitative level.

Section 4: Calibration for Innov-X Portable XRF

The Innov-X analyzer can run *three* different calibration methods, described below.

COMPTON NORMALIZATION:

In nearly all cases, customers use the Compton Normalization method. This method (recognized in EPA 6200) offers speed, ease of use, and generally good accuracy for concentration ranges from the ppm level up to 2-3% concentrations. As most field-testing is seeking to remediate or locate environmental contaminants, the upper limit of the calibration (2-3%) is generally not a limitation.

FUNDAMENTAL PARAMETERS (FP):

If customers do require a calibration up to 100% concentration (i.e. a pure element), then Innov-X recommends they also include the Fundamental Parameters (FP) software module with the analyzer. The FP module may be added at time of purchase or as an upgrade at any later date.



NOTE

In general, customers do not need to calibrate Innov-X analyzers for soil testing. The analyzer is delivered with a factory calibration, generally based upon the Compton Normalization (CN) method. The CN method has been proven over the past several years to provide a robust calibration generally independent of site-specific soil matrix chemistry. All customers should follow the QC procedure described in Section 3, which includes a check of the calibration.

EMPIRICAL CALIBRATION:

In this case, customers run standards to generate calibration curves for various elements in specific soil matrices. With a well-prepared sample, the empirical method generally yields the most accurate result. In our experience, the accuracy gains going *from* Compton Normalization *to* Empirical Mode are small and not worth the extra effort in setting up calibration curves.

The empirical calibration module is an optional software package, available for an upgrade fee at the time of purchase, or as an upgrade at any later date.



CAUTION

The *greatest source of error* for in-field XRF analysis of soil is *lack of adequate sample preparation*, thus there is little gained in developing a sophisticated empirical calibration if the operator does not grind and homogenize the all measured samples.

Calibration Requirements:

The concentration of an element in a soil sample is well-described by the formula:

$$w_i = \frac{k_i}{M(Z, i)} I_i$$

where:

k_i = calibration constant for element i

ω_i = concentration of element i - the quantity being measured

I_i = measured x-ray intensity from element i

$M(Z, I)$ = Soil matrix value

The factory calibration determines the value of the calibration constants k_i for each element, and a typical value $M(Z, I)$. The calibration method - either CN, fundamental parameters, or empirical - performs the necessary corrections to the value $M(Z, I)$ that are important for the site-specific soil chemistry. The XRF analyzer uses the measured intensity of each element's fluorescence from the sample, and the calibration data, to produce elemental concentrations.

COMPTON NORMALIZATION CALIBRATION:

The Compton Normalization method calibration consists of the analysis of a single, well-characterized standard, such as an SRM or SSCS. The standard data are normalized to the Compton peak. The Compton peak is produced from incoherent backscattering of X-ray radiation from the excitation source and is present in the spectrum of every sample. The matrix affects the way in which source radiation is scattered off the samples. This scatter is directly related to the intensity of the Compton peak. For that reason, normalizing to the Compton peak can reduce problems with matrix effects that vary among samples. Compton normalization is similar to the use of internal standards in analysis for organic analytes.

FUNDAMENTAL PARAMETERS CALIBRATION:

The fundamental parameters (FP) calibration is a *standardless* calibration. Rather than establishing a unit's calibration curve by measuring its response to standards that contain analytes of known concentrations, FP calibration relies on the known physics of the spectrometer's response to pure elements to set the calibration. Built-in mathematical algorithms are used to adjust the calibration for analysis of soil samples and to compensate for the effects of the soil matrix. The FP calibration is performed by the manufacturer, but the analyst can adjust the calibration curves (slope and y-intercept) on the bases of results of analyses of check samples, such as SRMs which are analyzed in the field.

EMPIRICAL CALIBRATION:

The empirical calibration method requires that a number of site-specific calibration standards (SSCS) are used to establish calibration parameters. The instrument response to known analytes is measured and used to create calibration curves. Empirical calibration is effective because the samples used closely match the sample matrix. SSCSs are well-prepared samples collected from the site of interest in which the concentrations of analytes have been determined by inductively coupled plasma (ICP), atomic absorption (AA), or other methods.

The standards should contain all the analytes of interest and interfering analytes. Manufacturers recommend that 10 to 20 calibration samples be used to generate a calibration curve. The empirical method is the least desirable calibration method as it requires that new standards and curves are generated for each site that is analyzed.

Section 5: Effects of Moisture on XRF Results

Sample moisture has two effects on XRF results:

- It alters the soil chemistry, since water is another chemical compound that comprises the soil matrix.
- Moisture impedes the ability to properly prepare samples.

There is a further testing consideration:

- Laboratory results are provided on a *dry weight* basis.

EFFECT ON SOIL CHEMISTRY:

While the presence of significant moisture does impact the soil chemistry, modern XRF analyzers all perform automatic corrections for variations in soil chemistry from site to site. Indeed, such variations are expected, and that is the reason analyzers use Compton Normalization or fundamental parameters, in order to correct for moisture content changes as well as other differences in soil geochemistry.

It is known that moisture content above 20 percent may cause problems, since moisture alters the soil matrix for which the FPXRF has been calibrated. However, the Compton Normalization or fundamental parameters methods are implemented in order to automatically correct results for changes to the soil matrix. Thus, we believe that soil moisture is not a significant effect on accuracy due to effects of soil matrix, except for the *dilution* effect that can cause discrepancies with laboratory results which is described below.

SAMPLE PREPARATION ISSUES:

The inability to adequately prepare a wet sample is, we believe, the single biggest contributor to errors when testing wet samples. It is very difficult to grind or sieve a wet sample. The highest quality XRF results are generally obtained from prepared samples.



CAUTION

If the operator is unwilling to dry the sample to prepare it, comparisons to the laboratory may yield poorer correlation since the samples are not homogeneous.

Laboratory Tests on Dry-Weight Basis:

Laboratories always dry samples prior to analysis. They report percent weight content based upon a dry sample basis. Portable XRF may often be used to analyze wet samples in the field, and results are thus reported that include the moisture content. Thus, with all other factors the same, the laboratory will report results higher than portable XRF. The results are higher by the amount of moisture content in the sample. For example, laboratory results will be 10% higher compared to XRF results, if the sample contained 10% by weight water when it was tested with XRF. Recall, this applies to samples where other possible sources of error are the same or negligible.

Section 6: Comparing XRF Results to Laboratory Results

Innov-X strongly recommends that operators compare prepared sample results to laboratory results. This is because prepared-sample results yield the best possible accuracy with portable XRF. Moreover, the most common source of error is due to non-uniform samples. No analytical technique, including the XRF technique, can properly account for non-uniform sample types.

To perform a comparison between XRF results and laboratory:

1. Collect a sample and prepare it according to the sample preparation guide given in *"Section 8: Sample Prep Procedures and Testing Protocols"* on [page 90](#).
2. Take a sub-sample (5-10 grams) of the fully-prepared sample, place it into an XRF cup and perform at least a one-minute test on that sample.
3. Send the same sample to the laboratory for wet chemistry analysis.
4. Require the laboratory to use a *total-digestion method*. If the laboratory does not, they may not extract all of the elemental metal from the sample. In this case, the lab result will be lower than the XRF result. Incomplete sample digestion is one of the *most common* sources of laboratory error, thus it is very important to request a total digestion method.

Example of Error: The operator collects a bag of sample, performs XRF analysis on one part of the bag, and sends the bag, or part of the bag of sample to a laboratory for analysis. The laboratory reports a very different value than the operator obtained with the XRF.

Problem:

Since the sample is very non-homogeneous, the operator did not obtain a result that was representative of the entire bag of sample. The lab analyzed a different part of the sample and obtained a very different result due to the non-uniformity of the sample. The solution to this problem is, at a minimum, to test several locations in the bag of sample and report the average value. Also note the differences between the tests, as this is indicative of the non-uniformity of the sample. The operator should send entire bag of sample to the lab, and instruct the lab to prepare the sample before removing the sub-sample for lab analysis.

Best Practice:

The operator should homogenize and prepare the entire bag of sample, and then collect a sub-sample for XRF testing. After testing, the *same sample* should be sent to the lab.

Section 7: Common Interferences

Interference occurs when the spectral peak from one element overlaps either partially or completely with the spectral peak of another.

Case 1 Conditions

If the instrument is calibrated for both elements, one causing the interference and one being interfered with, it is generally capable of correctly handling the interference. In this instance, the element being interfered with may be measured with a poorer detection limit or poorer precision, but the analytical results should still be acceptable for field-portable XRF.

Case 2 Conditions

If the XRF is not calibrated for the element causing the interference, then the instrument may report the presence of elements not in the sample, or greatly elevated concentrations of elements in or not in the sample.

Example CASE 1: Lead and arsenic

Lead and arsenic. Most XRFs are calibrated for lead and arsenic. Lead interferes with arsenic (not vice-versa though). The net effect is a worsened detection limit for arsenic, and poorer precision. The XRF handles the correction automatically, but the precision is affected. The loss of precision is also reported by the XRF.

(Refer to Innov-X Applications Sheet: [In-field Analysis of Lead and Arsenic in Soil Using Portable XRF](#) which is now available as [Arsenic and Lead in Soil.PDF](#) for more detail).

Example CASE 2: Bromine

Bromine in the sample, but the XRF is not calibrated for bromine. Bromine, as a fire retardant, is being seen more and more in soil and other sample types. For this reason, Innov-X analyzers include Br in the calibration data. If Br is not calibrated, but is present in the sample, the analyzer will report highly elevated levels of Pb, Hg and As. The levels will depend upon the concentration of Br in the sample.

Interferences between elements can be broadly categorized into two types:

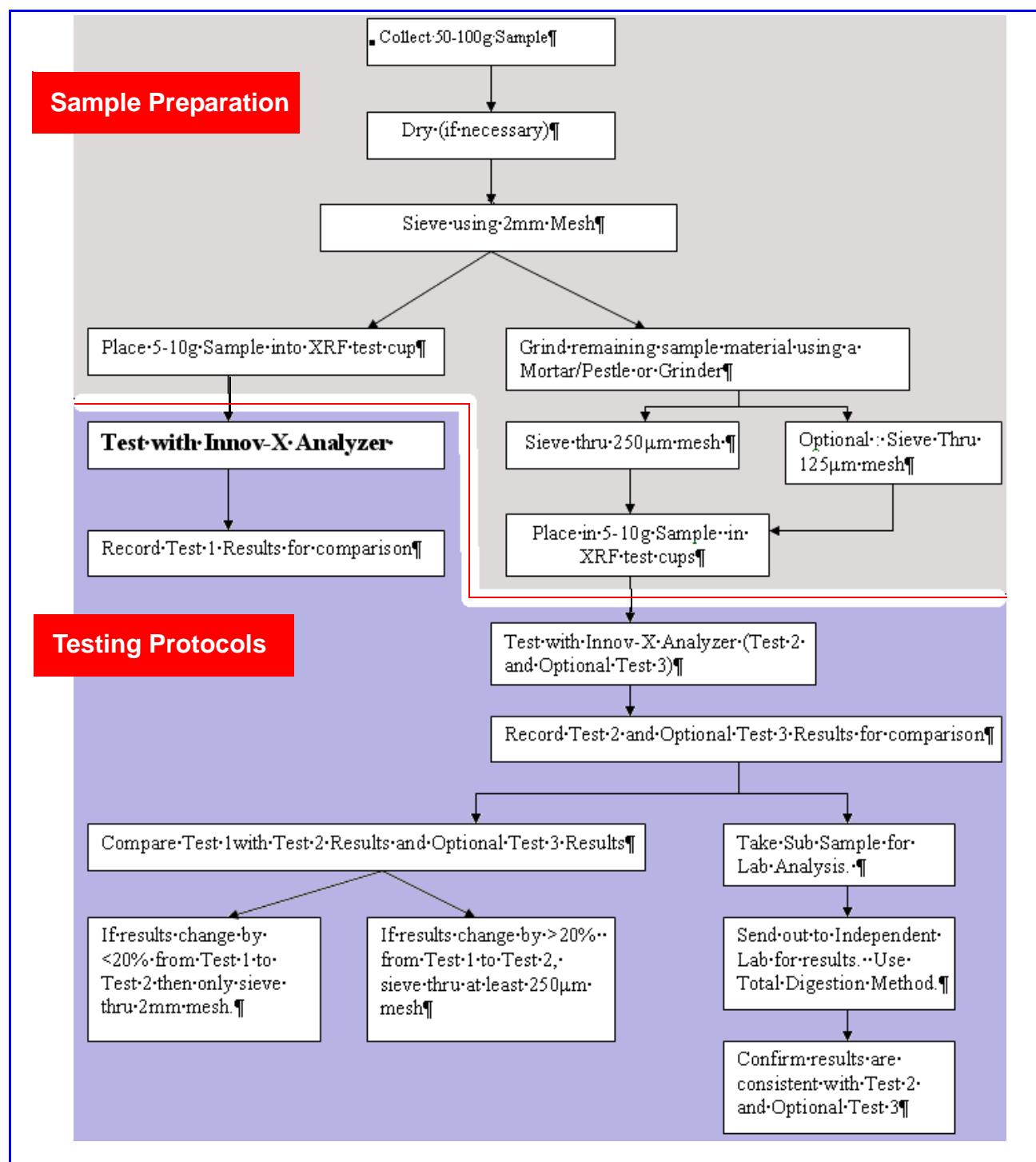
Z, Z-1, Z+1 interferences

Occurs when high levels of an element of atomic number Z are present. This can cause elevated levels of elements with atomic number Z-1 or Z+1. Generally, portable XRFs have good correction methods, so this interference only causes problems with very high levels of the element in question. Example: High concentrations of Fe (Z=26) in excess of 10% may cause elevated levels of Mn or Co (Z=25 or Z=27 respectively).

K/L interferences

Occurs when the L-shell line of one element overlaps with the K-shell spectral line of another element. The most common example is the lead/arsenic interference where the L-alpha line of lead is in nearly the exact same location as the K-alpha line of arsenic.

Section 8: Sample Prep Procedures and Testing Protocols



Section 9: NIST Certificates of Analysis

Innov-X systems provides three NIST standards (subject to change with availability). Each standard's certified values are given in Table 1 and Non-certified values are in Table 2 in the graphics below.

☒ SRM2709

☐ SRM2710

☐ SRM2711

Table 1. Certified Values

Element	Mass Fraction (%)	Element	Mass Fraction (µg/g)
Aluminum	7.50 ± 0.06	Antimony	7.9 ± 0.6
Calcium	1.89 ± 0.05	Arsenic	17.7 ± 0.8
Iron	3.50 ± 0.11	Barium	968 ± 40
Magnesium	1.51 ± 0.05	Cadmium	0.38 ± 0.01
Phosphorus	0.062 ± 0.005	Chromium	130 ± 4
Potassium	2.03 ± 0.06	Cobalt	13.4 ± 0.7
Silicon	29.66 ± 0.23	Copper	34.6 ± 0.7
Sodium	1.16 ± 0.03	Lead	18.9 ± 0.5
Sulfur	0.089 ± 0.002	Manganese	538 ± 17
Titanium	0.342 ± 0.024	Mercury	1.40 ± 0.08
		Nickel	88 ± 5
		Selenium	1.57 ± 0.08
		Silver	0.41 ± 0.03
		Strontium	231 ± 2
		Thallium	0.74 ± 0.05
		Vanadium	112 ± 5
		Zinc	106 ± 3

Table 2. Noncertified Values

Element	Mass Fraction (%)	Element	Mass Fraction (µg/g)
Carbon	1.2	Cerium	42
		Cesium	5.3
		Dysprosium	3.5
		Europium	0.9
		Gallium	14
		Gold	0.3
		Hafnium	3.7
		Holmium	0.54
		Iodine	5
		Lanthanum	23
		Molybdenum	2.0
		Neodymium	19
		Rubidium	96
		Samarium	3.8
		Scandium	12
		Thorium	11
		Tungsten	2
		Uranium	3
		Ytterbium	1.6
		Yttrium	18
		Zirconium	160

SRM2709



SRM2710

SRM2711



National Institute of Standards & Technology

Certificate of Analysis

Standard Reference Material® 2710

Montana Soil

Highly Elevated Trace Element Concentrations

This Standard Reference Material (SRM) is intended primarily for use in the analysis of soils, sediments, or other materials of a similar matrix. SRM 2710 is a highly contaminated soil that was oven-dried, sieved, radiation sterilized, and blended to achieve a high degree of homogeneity. A unit of SRM 2710 consists of 50 g of the dried material.

The certified elements for SRM 2710 are given in Table 1. The values are based on measurements using one definitive method or two or more independent and reliable analytical methods. Noncertified values for a number of elements are given in Table 2 as additional information on the composition. The noncertified values should NOT be used for calibration or quality control. Analytical methods used for the characterization of this SRM are given in Table 3 along with analysts and cooperating laboratories. All values (except for carbon) are based on measurements using a sample weight of at least 250 mg. Carbon measurements are based on 100 mg samples.

Noncertified Values: Noncertified values shown below are provided for information only. An element concentration value is not certified if a bias is suspected in one or more of the methods used for certification, or if two independent methods are not available.

Table 2. Noncertified Values

Element	Mass Fraction (%)	Element	Mass Fraction (mg/kg)
Carbon	3	Bromine	6
		Cerium	57
		Cesium	107
		Chromium	39
		Cobalt	10
		Dysprosium	5.4
		Europium	1
		Gallium	34
		Gold	0.6
		Hafnium	3.2
		Holmium	0.6
		Indium	5.1
		Lanthanum	34
		Molybdenum	19
		Neodymium	23
		Rubidium	120
		Samarium	7.8
		Scandium	8.7
		Strontium	330
		Thallium	1.3
		Thorium	13
		Tungsten	93
		Uranium	25
		Ytterbium	1.3
		Yttrium	23

Table 1. Certified Values

Element	Mass Fraction (%)	Element	Mass Fraction (mg/kg)
Aluminum	6.44 ± 0.08	Antimony	38.4 ± 3
Calcium	1.25 ± 0.03	Arsenic	626 ± 38
Iron	3.38 ± 0.10	Barium	707 ± 51
Magnesium	0.853 ± 0.042	Cadmium	21.8 ± 0.2
Manganese	1.01 ± 0.04	Copper	2950 ± 130
Phosphorus	0.106 ± 0.015	Lead	5532 ± 80
Potassium	2.11 ± 0.11	Mercury	32.6 ± 1.8
Silicon	28.97 ± 0.18	Nickel	14.3 ± 1.0
Sodium	1.14 ± 0.06	Silver	35.3 ± 1.5
Sulfur	0.240 ± 0.006	Vanadium	76.6 ± 2.3
Titanium	0.283 ± 0.010	Zinc	6952 ± 91

SRM2709

SRM2710



SRM2711



National Institute of Standards & Technology

Certificate of Analysis

Standard Reference Material® 2711

Montana Soil

Moderately Elevated Trace Element Concentrations

This Standard Reference Material (SRM) is intended primarily for use in the analysis of soils, sediments, or other materials of a similar matrix. SRM 2711 is a moderately contaminated soil that was oven-dried, sieved, radiation sterilized, and blended to achieve a high degree of homogeneity. A unit of SRM 2711 consists of 50 g of the dried material.

The certified elements for SRM 2711 are given in Table 1. The values are based on measurements using one definitive method or two or more independent and reliable analytical methods. Noncertified values for a number of elements are given in Table 2 as additional information on the composition. The noncertified values should NOT be used for calibration or quality control. Analytical methods used for the characterization of this SRM are given in Table 3 along with analysts and cooperating laboratories. All values (except for carbon) are based on measurements using a sample weight of at least 250 mg. Carbon measurements are based on 100 mg samples.

Noncertified Values: Noncertified values, shown below, are provided for information only. An element concentration value may not be certified, if a bias is suspected in one or more of the methods used for certification, or if two independent methods are not available.

Table 2. Noncertified Values

Element	Mass Fraction (%)	Element	Mass Fraction (µg/g)
Carbon	2	Bromine	5
		Cerium	69
		Cesium	6.1
		Chromium	47
		Cobalt	10
		Dysprosium	5.6
		Europium	1.1
		Gallium	15
		Gold	.03
		Hafnium	7.3
		Holmium	1
		Indium	1.1
		Iodine	3
		Lanthanum	40
		Molybdenum	1.6
		Neodymium	31
		Rubidium	110
		Samarium	5.9
		Scandium	9
		Thorium	14
		Tungsten	3
		Uranium	2.6
		Ytterbium	2.7
		Yttrium	25
		Zirconium	230

Table 1. Certified Values

Element	Mass Fraction (%)	Element	Mass Fraction (µg/g)
Aluminum	6.53 ± 0.09	Antimony	19.4 ± 1.8
Calcium	2.88 ± 0.08	Arsenic	105 ± 8
Iron	2.89 ± 0.06	Barium	726 ± 38
Magnesium	1.05 ± 0.03	Cadmium	41.70 ± 0.25
Phosphorus	0.086 ± 0.007	Copper	114 ± 2
Potassium	2.45 ± 0.08	Lead	1162 ± 31
Silicon	30.44 ± 0.19	Manganese	638 ± 28
Sodium	1.14 ± 0.03	Mercury	6.25 ± 0.19
Sulfur	0.042 ± 0.001	Nickel	20.6 ± 1.1
Titanium	0.306 ± 0.023	Selenium	1.52 ± 0.14
		Silver	4.63 ± 0.39
		Strontium	245.3 ± 0.7
		Thallium	2.47 ± 0.15
		Vanadium	81.6 ± 2.9
		Zinc	350.4 ± 4.8

NOTES

A3. Specifications

Handheld Analyzer	Description
Weight	3.35 lbs. (Base wt.), 3.70 lbs. (1.6 kg) with battery
Excitation Source	4 Watt X-ray tube - Au, Ag, Rh, or Ta anode (application optimized), 8-40 keV, 5 - 200 μ A, eight filter positions
Detector	Various: Si PIN diode or Si Drift detector, thermo-electrically cooled, high resolution
Power	Removable Li-ion batteries, or AC power unit
Battery Life	Battery life varies depending on usage patterns
Display	Color "transflective" touchscreen (800 x 600) with 16-bit LCD interface)
Cal Check Coupon	316 Stainless Steel Alloy -- see also Docking Station
Power Requirements for AC Adapter	110-220 VAC, 50-60 Hz, 600 W max (P/N 100043)
Pressure Correction	Built-in barometer for automatic altitude correction
Operating Environment	Temperature: -10°C to 45°C Humidity: 10 to 90% Relative Humidity, non-condensing Altitude Rating: 2000 meters
Operating System	Windows Embedded CE [®]
Application Software	Innov-X Systems' proprietary Data Acquisition and Processing package.
USB Interface	USB 2.0
Docking Station	Description
Dimensions	L=14.0 in x W=8.75 in x H=4.75 in (H w/ spare battery = 6.5 in); Wt = 3.25 lbs.
Power Requirement	AC adapter standard: 110-220 VAC, 50-60 Hz, 600 W max
Cal Check Cup	Automatically performs Cal Check on inserted instrument
Battery Charging	Charges battery in unit; can simultaneously charge spare battery in separate socket
Accessories	Description
AC Battery Charger	P/N 120253
TestStand/Workstation	A-020-D - portable equipment stand making a fully shielded closed beam system. Uses Delta PC Software.
Soil Foot	A-035
Soil Extension Pole	P/N 990055
Trimble Xploration Package (P6000FDC)	XPLOER FIELD DATA COLLECTION BUNDLE Trimble Nomad 800G-LC - Ruggedized 800Mhz Field Computer with integrated GPS, Wi-Fi, Bluetooth, Camera, 16Gb Memory, SD Card Slot Options: Barcode Scanner, Cell Phone Interface, Fully DGPS compatible running Windows Mobile 6.0 OS.

Operating specifications are posted as nominal.

Trimble Xploration
Package
(P6000TFG)

XPLOER TOTAL FIELD GEOCHEM BUNDLE

Includes all features supplied with **Field Data Collection Package** and:
Soil Extension Pole - Ergonomic extension pole facilitating soil analysis by a standing (and walking) operator.

Soil Foot - Attaches to nose of DELTA analyzer balancing analyzer on ground for hands-free, extended in-situ testing.

ioGAS - ioAnalytics GeoChemical Analysis Software Suite, an advanced spatial data analysis package for visualization, interrogation & validation of geochemical data for mineral exploration, mining, & environmental industries.

A4. Typical Delta Test Sequence

Innov-X Delta User Interface

Operators manage their measurement, analysis, and results activities from the *Innov-X* UI when in ANY of the Alloy modes/calibrations. This Appendix presents:

- Typical Sample Test Procedure, and
- Prerequisites for testing necessary for various modes



GO TO

The operational features of the *Home*, *Mode*, *Setup*, *Test*, and *Results* screens are explained in "*Delta User Interface Guide*" (PN 103202). In this document, "*Delta User Manual*," see *C4, Operations, Page 47* for a SNAPSHOT of the UI.

Typical Sample Test Procedure

This sample procedure features the **Alloy Plus** mode.

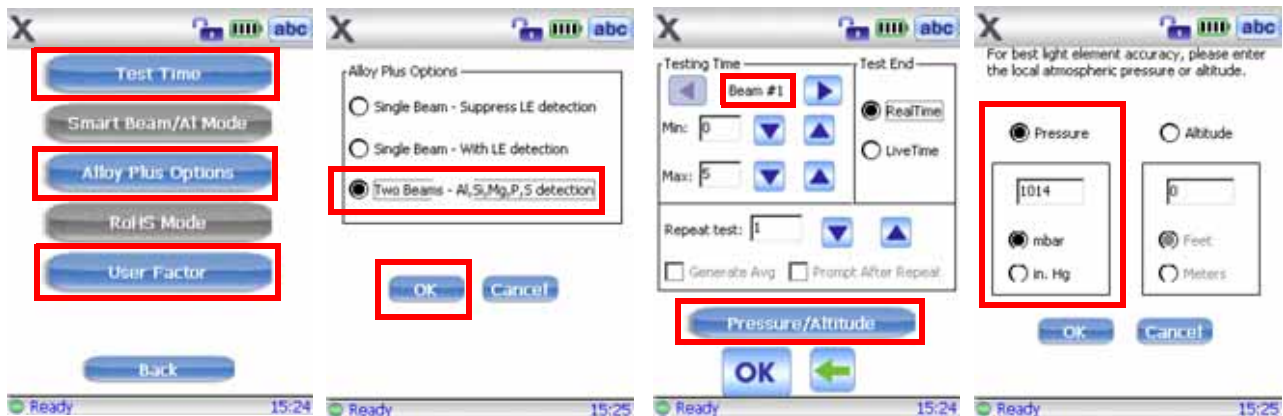
Other modes follow a similar sequence, however, the **Test Condition** screens are generally unique to each testing situation.

Use these steps:

1. From the **Home** screen, tap **Mode** icon
2. From **Mode** screen, tap the **Alloy Plus** icon
3. Select **Mode Setup** button



4. Select **Test Conditions**, then **Test Time**
5. Ensure that the **Testing Time** and other parameters are properly selected



6. Press OK button, the Back, then OK again
7. Return to Home screen, select Test to call the *Test-Alloy Plus* screen

Testing Tips for Certain Modes

Alloy:

- Place the analyzer's window on/over the test specimen, cover the window completely.
- Remember the Safety information ([C2, Pages 29-31](#)) to ensure your own personal safety.
- Take care not to damage the window film, such as when testing "metal turnings" or hot surfaces.

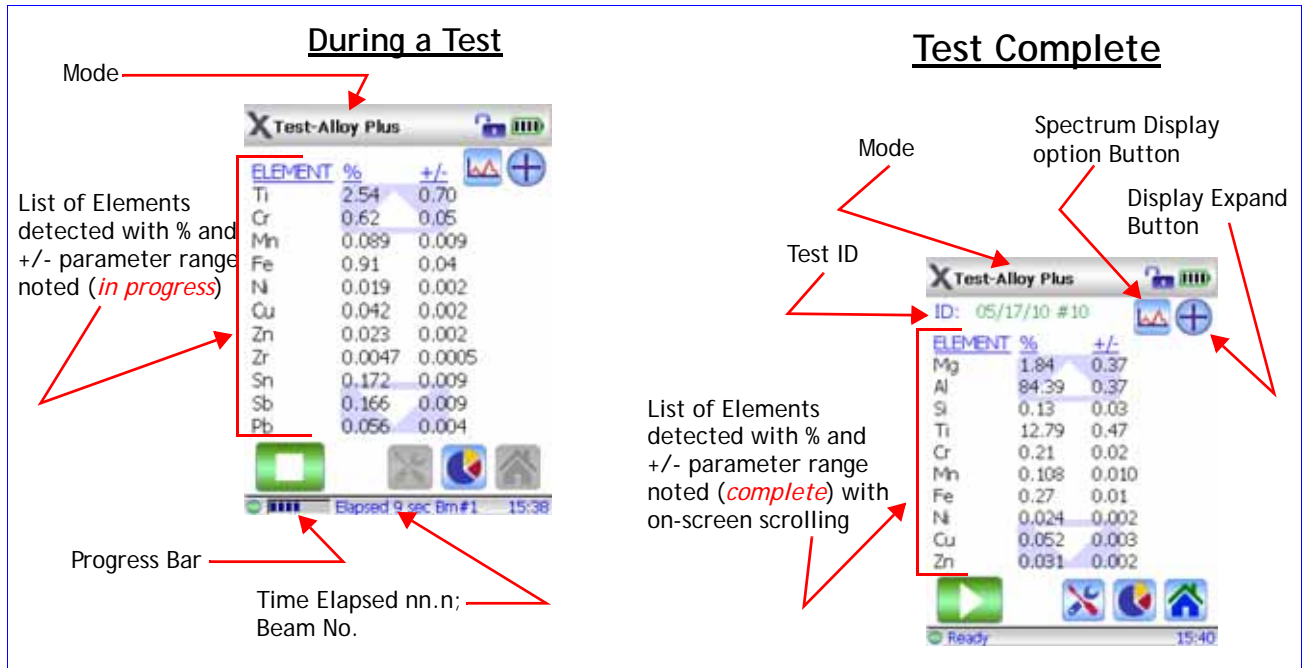
Soil or Mining:

- Place the analyzer's measurement window directly over the sample cup with the film side up.
- Specify the altitude or atmospheric pressure to gain increased accuracy for light elements.
- Confirm that the Testing Time and other parameters are properly selected
- Take care not to damage the window film, such as when testing uneven surfaces

RoHS:

- In order for XRF testing to be *quantitative*, samples must be:
 - Homogeneous
 - Have a certain minimum sample thickness
 - Five (5) mm for polymers and light alloys
 - Fifteen (15) mm for liquid samples
 - One (1) mm for other alloys
- If samples are heterogeneous, too thin, or too small, only *qualitative* screening is possible.

8. Start a new test by using one of these methods:
 - a. Tap Start button on the UI (toggles Delta to X-ray ON state)
 - or —
 - b. Pull the trigger (toggles instrument to X-ray ON state)
 - or —
 - c. Pull-and-hold the trigger when the "Deadman Trigger" is active.



Best Practices for Testing

Alloy Mode

Prior to a test session, analysts should have an understanding of *Innov-X's* implementation of:

- **Grade Libraries** -> populated by alloy Grades -> their chemistry characterized by Grade Tables.
See [Grade Libraries](#) for library management procedures.
- **Match Issues** including the concept and use of Match Numbers.
See [Match Issues](#)

Prior to initiating testing with the analyzer software, ensure that the following tasks are complete:

1. Analyzer does not require a Cal Check procedure.
2. The analyzer's measurement window is properly positioned in front of or over the test sample.
3. The *Match Cutoff* and *nSigma* parameters are configured.

Mining and Soil Modes

Check Standards

- Measure a **check standard** after each Cal Check, and periodically throughout the day. Test for a recommended minimum of one minute.
- Concentrations for elements of interest, in the range expected, plus or minus the error on the reading, should be within 20 percent of the standard value.
- [A2.Soil Testing](#) describes recommended quality assurance details.

- The standards provided with the analyzer are contained in XRF sample cups. These containers have a window (through which the soil can be viewed) on one side, and a solid cap on the other side.

Always measure samples through the window.

Sample Presentation

IN SITU TESTING

In situ testing is performed by pointing the analyzer at the ground. Clear any grass or large rocks away and hold the analyzer with the probe head front flush to the ground. Since dirt can accumulate on the analyzer window, gently wipe the window clean after each analysis. Ensure the window is not ripped or punctured.

BAGGED OR PREPARED SAMPLE TESTING

Analyze prepared samples in a sample cup, through its window. Place the instrument's measurement window directly over the sample cup with the film side up.

Preparation considerations include:

- Avoid measuring very thin samples, as this can affect results. Prepare samples cups to contain at least 15 (usually 4-8 grams) mm of packed samples.
- When analyzing bagged samples, ensure that sufficient sample material exists in the bag to create a sample thickness of a minimum of 15 mm for a spot size that is larger than the analyzer's measurement window.
- When using bags, cheaper bags (having thinner plastic walls) are better than more expensive ones (which have thicker plastic walls).

Consumer Mode

RoHS Best Practices

Check Standards

Innov-X Systems recommends that a check standard be measured after each Cal Check procedure, and periodically throughout the day.

Two certified standards are provided for verification.

- At least one standard should be measured for a minimum of two minutes.
- Concentrations for target elements (plus or minus the error on the reading) should be within 20% of the standard value.
- Standards provided are contained in XRF sample cups with a window (through which the plastic pellets can be viewed) on one side, and a solid cap on the other side.
- Samples should be measured in the sample cup, through the window.

Sample Presentation

Since many pieces of plastic analyzed for ROHS compliance are very small, take care to measure them in a safe and accurate manner.

See the IEC-ACEA recommendation for minimum thickness of test samples as shown in Chapter [C.8](#).

A5. User Maintenance

5.1 Alternative Techniques for Powering or Charging the Delta

5.1.1. AC Power Adapter Kit

The kit is an **optional** accessory.

It is supplied with a 10 foot AC power cord, a switching AC adapter, and a Battery Module. This kit eliminates the Li-ion battery requirement, however the user is constrained by the length of the AC power cord.

The procedure for using the AC adapter is shown below.



WARNING

Ensure that each AC supply circuit has adequate power load capability and is provided from a grounded AC receptacle.

TO SETUP THE ADAPTER:

1. Plug the three-prong male plug into the receptacle.

Female Plug →



← Male Plug

2. Insert the three-prong female plug into the male receptacle on the *Switching AC Adaptor* brick.



3. Slide the Battery Eliminator unit into the analyzer with the contacts to the left. It is keyed to only go in oriented this way.

Contacts →



4. The user now has no limit to instrument power; not restricted by battery charge level. The range of action is constrained by the length of the power cord.

5.1.2. Li ion Battery Charger Assembly

This section describes the procedure for charging the Li-ion batteries when the Delta Docking Station is **NOT** available. It features a single socket standalone battery charger (P/N 120253). The unit takes about two hours to completely charge a battery. Status of the battery's charge is shown by two lights on the power adaptor.

TO CHARGE THE BATTERY:

1. Plug the three-prong male plug into the Modes receptacle.



2. Plug the three-prong female plug into the male receptacle on the *AC Adaptor* brick.



3. Plug the connector labeled *CH4500 24 VDC* into the connector labeled *SWC* on the back of the charger.

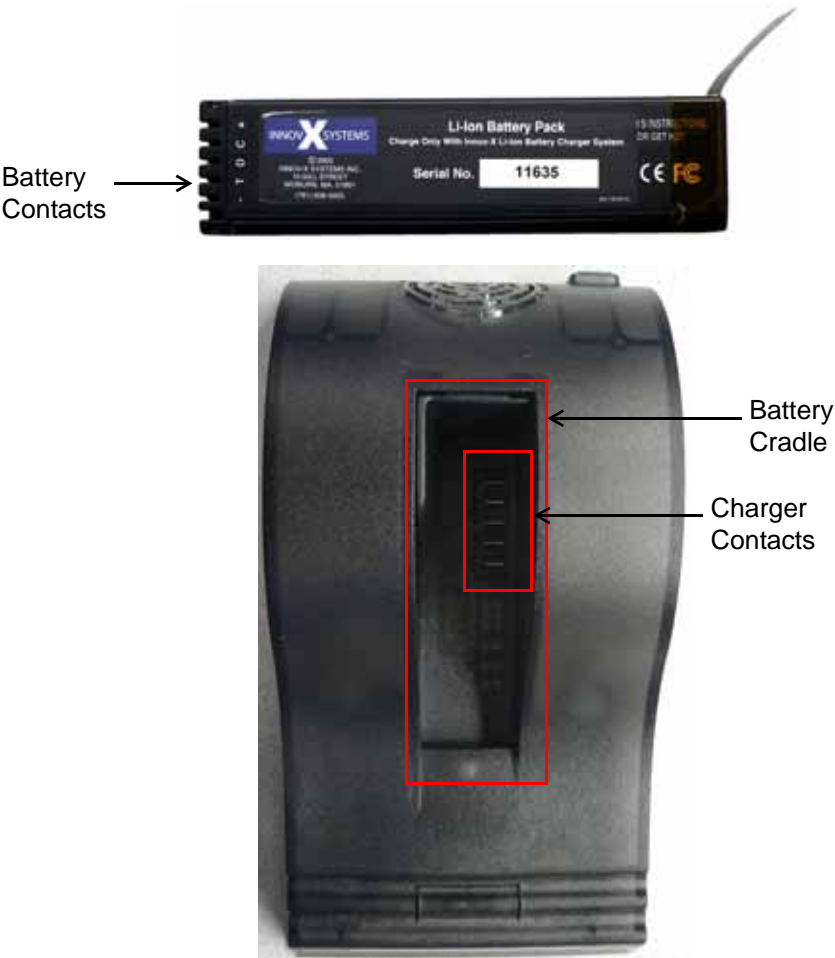


4. Insert the Li-ion battery into the charger with the contacts facing right.



CAUTION

Forcing the battery in with the contacts oriented improperly will injure the contacts and destroy the battery.



Battery Charger Status Lights

Left Light (Green only)	Right Light (Red only)	Status
On - Flashing	Off	Battery is charging
On - Solid	Off	Battery is charged
Off	On - Solid	Error. Remove battery and replace on charger. If the error persists, call Innov-X Systems Technical support.
Off	Off	No battery is on charger

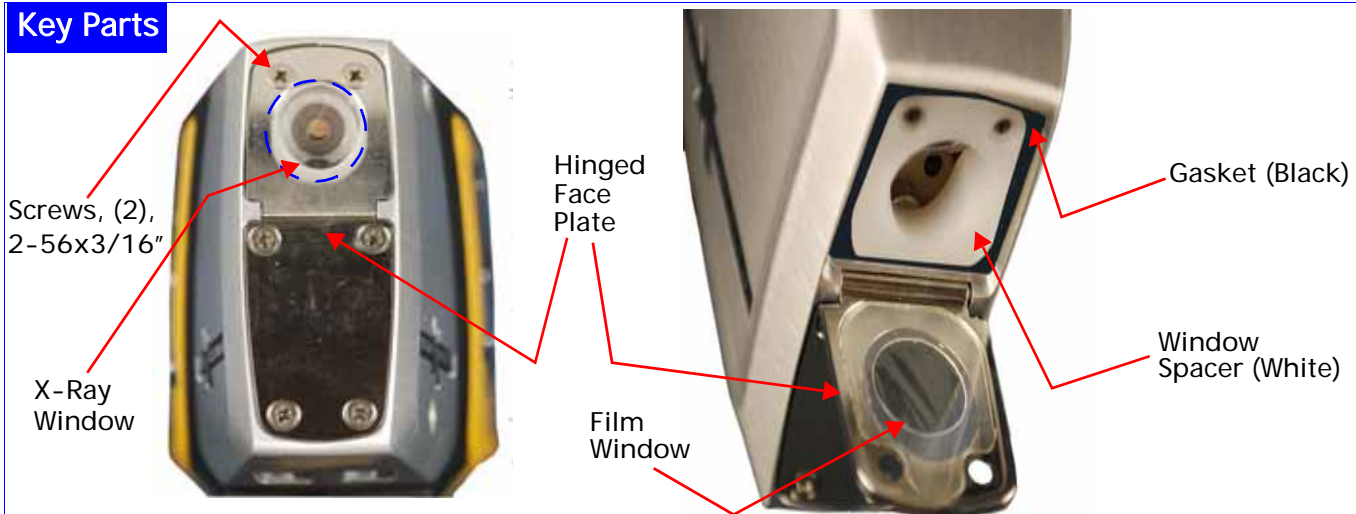


5.2 — Window Replacement for “Hinged Plate” Analyzers

How to Replace the Window on a Delta Analyzer (All Models)


Tools: *Required* - Small Phillips Head Screwdriver
Recommended - Tweezers or Needle nose pliers; Can of compressed air
As needed: - Lint-free wipes or swabs

Key Parts



Remove Old Window

Use these guidelines:

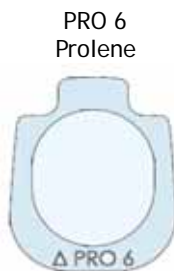
- During this entire removal process, keep dust or foreign material out of the instrument.
- Ensure that the instrument is powered off.
- Take care to have clean hands.
- Orient the instrument with the nose pointing up.
- Review the  TIPS section on next page **before** opening the hinged plate.
- Use Phillips head screwdriver to remove the two screws.
 - Carefully set aside the screws.
- Swing the hinged face plate out to expose the film window.
- Remove the old window.
- Observe the white plastic window spacer and the black rubber gasket
- Remove any dirt or foreign material from the gasket with compressed air
- Take EXTREME CARE to not harm any internal components



CAUTION Avoid expensive internal damage, DO NOT INSERT anything (fingers or tools) into the instrument.

Replacement Window Details

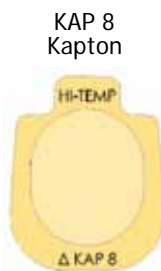
- Windows assemblies are made from either **Prolene**, **Mylar**, or **Kapton** film.
 - Users must specify the proper material to match their original application and calibration.
- The selected film is adhered to **one** side of a polyester backing plate; this creates a "front" and "back" surface
 - "Back" surface is completely covered with film.
 - "Front" surface shows a circular ridge where the film only is present, showing through the center hole of backing plate. This front surface also has a part type designator.
- Ensure that the "back" surface faces up when installing a new window (See below).



P/N: -->> 102999



103000



103173 (Hi-Temp)

103115 (Classic Standard)



Install Replacement

Follow these steps:

- Remove new window assembly from shipping envelope.
- Handle it by edges or use tweezers.
- Apply canned compressed air to clear any contaminants from the surfaces.
- Place window assembly on the hinged plate with **film back surface facing up**.
 - Center it to avoid the screw holes.
- Carefully rotate the hinged plate up to secure the window assembly.
- Insert the two screws; tighten only to "snug".
 - Don't over-tighten them or strip the threads.

TIPS



- Do not touch the film in the center opening (on either side).
- When using the screwdriver, keep a finger or thumb between the tool and the X-ray window. This prevents accidentally sticking the tool through the film and causing internal damage.
- The cost for replacement windows is quite low. Users are encouraged to change them frequently in order to obtain optimum test results.
- When not operating an instrument, experienced users routinely keep it the Delta Docking Station cradle.
 - This keeps the window clean, and
 - Prevents accidental damage to the window film, and
 - Takes advantage of the battery charging and Cal Checking procedure that the DDS offers.

NOTES

A6. Packing and Shipping

If the instrument is not returned in the protective case, it can be damaged during shipping. Innov-X Systems reserves the right to void the warranty on instruments that are damaged during return shipping that are sent without the protective case.

Prior to returning a unit, contact Customer Service at the appropriate depot:

— United States —		— Europe —	
<ul style="list-style-type: none">• Phone: 1-781-938-5005• Fax: 1-781-938-0128• Email: Service@Innov-Xsys.com	<ul style="list-style-type: none">• Mail & Shipping Address: Innov-X Systems, Inc. 100 Sylvan Road Woburn, MA 01801	<ul style="list-style-type: none">• Phone: +31 (0)73 62 72 590• Fax: +31 (0)73 62 72 599• Email: info@innovx-europe.com	<ul style="list-style-type: none">• Mail & Shipping Address: Innov-X Systems, Inc. Kasteleinenkampweg 9R 5222 AX 's-Hertogenbosch The Netherlands
— Canada —		— Australia —	
<ul style="list-style-type: none">• Phone: 1-778-960-6279• Fax: 1-604-568-2474• Toll Free Fax: 1-888-873-6598• Email: service@innovx.ca	<ul style="list-style-type: none">• Mail & Shipping Address: Innov-X Canada 1201 West Georgia, Ste. 2 Vancouver BC Canada V6E 3J5	<ul style="list-style-type: none">• Phone: 02 9577 9500• Fax: 02 9519 1850• Email: service@innovx.com	<ul style="list-style-type: none">• Mail & Shipping Address: Innov-X Systems Australia PTY LTD Suite 6, Level 3 215 Euston Road Alexandria NSW 2015 Australia

Or call your local distributor.

Ensure that you receive the required RMA number.

Follow these instructions to return your XRF Analyzer:

1. Pack the analyzer in the black protective case in which it arrived, using the original packing materials.
2. Include the RMA in the case and reference the RMA number in your shipping documents.
3. Close the protective case and either:
 - Secure it with plastic zip ties,
 - or —
 - Pack the protective case within another box.

Regulations for Shipping Products with Lithium Ion Batteries

The United States and many other countries have instituted regulations that require shippers to use a special Caution label referring to a Lithium Ion Battery.

- Label must be prominently displayed on the outer shipping container of any product that contains a Lithium Ion battery.
- Shipper may copy the label shown below to facilitate making the warning label. Use a color copier if possible.



A7. Legal Information

This section provides copies of the following:

- Delta Analyzer Limited Warranty including:
 - Limitation of Liability
 - Warranty Period, Returns, and Repairs
 - Instructions for Contacting Innov-X
- End User Software License Agreement including:
 - Use, Restrictions, and Termination of Software
 - Governmental End User Conditions
 - Limited Warranty and Limitation of Liability

Innov-X Delta Analyzer Limited Warranty

General Terms

EXCEPT AS EXPRESSLY SET FORTH IN THIS LIMITED WARRANTY, INNOV-X SYSTEMS, INC. (INNOV-X) MAKES NO OTHER WARRANTIES OR CONDITIONS, EXPRESSED OR IMPLIED, INCLUDING ANY IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. INNOV-X EXPRESSLY DISCLAIMS ALL WARRANTIES AND CONDITIONS NOT STATED IN THIS LIMITED WARRANTY. ANY IMPLIED WARRANTIES THAT MAY BE IMPOSED BY LAW ARE LIMITED IN DURATION TO THE LIMITED WARRANTY PERIOD.

This Limited Warranty applies to Innov-X analyzers sold or leased from Innov-X, its affiliates, authorized resellers, or country distributors (collectively referred to in this Limited Warranty as "Innov-X.")

Innov-X warrants that the analyzer and all its internal and external components that you have purchased are free from defects in materials or workmanship under normal use during the Limited Warranty Period. The Limited Warranty Period starts on the date of shipment by Innov-X. You may be required to provide proof of purchase or lease as a condition of receiving warranty service. You are entitled to warranty service according to the terms and conditions of this document if a repair to your Innov-X analyzer is required within the Limited Warranty Period.

During the Limited Warranty Period, Innov-X will repair or replace the defective component parts. All component parts removed under this Limited Warranty become the property of Innov-X. In the unlikely event that your Innov-X analyzer has a recurring failure, Innov-X, at its discretion, may elect to provide you with a replacement unit of Innov-X's choosing that is at least equivalent to your Innov-X analyzer. This is your exclusive remedy for defective products. The repaired or replacement analyzer is warranted for the remainder of the limited Warranty Period.

YOU SHOULD MAKE PERIODIC BACKUP COPIES OF THE DATA STORED ON THE ANALYZER'S SYSTEM COMPUTER AS A PRECAUTION AGAINST POSSIBLE FAILURES, ALTERATION, OR LOSS OF THE DATA. BEFORE RETURNING ANY UNIT FOR SERVICE, BE SURE TO BACK UP DATA AND REMOVE ANY CONFIDENTIAL, PROPRIETARY, OR PERSONAL INFORMATION. INNOV-X IS NOT RESPONSIBLE FOR DAMAGE TO OR LOSS OF ANY PROGRAMS, OR DATA. INNOV-X IS NOT RESPONSIBLE FOR THE RESTORATION OR REINSTALLATION OF ANY PROGRAMS OR DATA OTHER THAN SOFTWARE INSTALLED BY INNOV-X WHEN THE ANALYZER IS MANUFACTURED.

Innov-X does not warrant that the operation of this analyzer will be uninterrupted or error-free. Innov-X is not responsible for damage that occurs as a result of your failure to follow the instructions that came with the Innov-X analyzer.

This Limited Warranty does not apply to expendable parts. This Limited Warranty does not extend to any analyzer from which the serial number has been removed or that has

been damaged or rendered defective (a) as a result of accident, misuse, abuse, or other external causes; (b) by operation outside the usage parameters stated in user documentation that shipped with the product; (c) by modification or service by anyone other than (i) Innov-X, or (ii) an Innov-X authorized service provider; (d) installation of software not approved by Innov-X.

These terms and conditions constitute the complete and exclusive warranty agreement between you and Innov-X regarding the Innov-X analyzer you have purchased or leased. These terms and conditions supersede any prior agreements or representations --- including representations made in Innov-X sales literature or advice given to you by Innov-X or any agent or employee of Innov-X --- that may have been made in connection with your purchase or lease of the Innov-X analyzer. No change to the conditions of this Limited Warranty is valid unless it is made in writing and signed by an authorized representative of Innov-X.

Limitation of Liability

IF YOUR INNOV-X ANALYZER FAILS TO WORK AS WARRANTED ABOVE, YOUR SOLE AND EXCLUSIVE REMEDY SHALL BE REPAIR OR REPLACEMENT. INNOV-X'S MAXIMUM LIABILITY UNDER THIS LIMITED WARRANTY IS EXPRESSLY LIMITED TO THE LESSER OF THE PRICE YOU HAVE PAID FOR THE ANALYZER OR THE COST OF REPAIR OR REPLACEMENT OF ANY COMPONENTS THAT MALFUNCTION IN CONDITION OF NORMAL USE.

INNOV-X IS NOT LIABLE FOR ANY DAMAGE CAUSED BY THE PRODUCT OR THE FAILURE OF THE PRODUCT TO PERFORM INCLUDING ANY LOST PROFITS OR SAVINGS OR SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES. INNOV-X IS NOT LIABLE FOR ANY CLAIM MADE BY A THIRD PARTY OR MADE BY YOU FOR A THIRD PARTY.

THIS LIMITATION OF LIABILITY APPLIES WHETHER DAMAGES ARE SOUGHT, OR A CLAIM MADE, UNDER THIS LIMITED WARRANTY OR AS A TORT CLAIM (INCLUDING NEGLIGENCE AND STRICT PRODUCT LIABILITY), A CONTRACT CLAIM, OR ANY OTHER CLAIM. THIS LIMITATION OF LIABILITY CANNOT BE WAIVED OR AMENDED BY ANY PERSON. THIS LIMITATION OF LIABILITY WILL BE EFFECTIVE EVEN IF YOU HAVE ADVISED INNOV-X OR AN AUTHORIZED REPRESENTATIVE OF INNOV-X OF THE POSSIBILITY OF ANY SUCH DAMAGES.

Software

This Limited Warranty does not warrant software products. The Innov-X software installed on the analyzer's system computer is covered by the Innov-X End User Software License Agreement.

Warranty Period

The warranty period for an Innov-X Delta Analyzer is one year. This warranty does not extend to expendable parts. Extended warranties are available from Innov-X.

Warranty Returns

A Return Material Authorization (RMA) Number must be obtained from the INNOV-X Service Department before any items can be shipped to the factory. Returned goods will not be accepted without an RMA Number. Customer will bear all shipping charges for warranty repairs. All goods returned to the factory for warranty repair should be properly packed to avoid damage and clearly marked with the RMA Number.

Warranty Repairs

Warranty repairs will be done either at the customer's site or at the INNOV-X plant, at our option. All service rendered by INNOV-X will be performed in a professional manner by qualified personnel.

Contacting Innov-X

Be sure to have the following information available before you call Innov-X:

- Analyzer serial number, model name, and model number
- Applicable error messages
- Description of problem
- Detailed questions

Methods of Contact

— United States —

- Phone: 1-781-938-5005
- Fax: 1-781-938-0128
- Email: Service@Innov-Xsys.com
- Mail & Shipping Address: Innov-X Systems, Inc.
100 Sylvan Road
Woburn, MA 01801

— Canada —

- Phone: 1-778-960-6279
- Fax: 1-604-568-2474
- Toll Free FAX: 1-888-873-6598
- Email: service@innovx.ca
- Mail & Shipping Address: Innov-X Canada
1201 West Georgia, Ste. 2
Vancouver BC
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— Europe —

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A8. Alloy Grade Libraries

Every Delta unit is supplied with four libraries:

1. "Factory" Library unique to every Model
 - See following pages for tables showing Model/Factory grade names
2. Tramp Library
3. User Library #1 (user may store more than 500 grade names)
4. User Library # 2 (user may store more than 500 grade names)

Libraries are editable. However, InnovX does not recommend that users edit the "Factory" grade library.

Tramp Library

Every analyzer is shipped with a "Tramp" library comprised of seven base alloys. The "Tramp" library supports other grade libraries.

Users can set Tramp Limits, element by element, alloy base by alloy base, to meet their specific requirements.

A single click can select/deselect (globally) the Tramp feature.

How the Tramp Library works:

1. Tramp Grades are matched to alloy bases rather than specific grades.
 - Each sample is determined to be one of seven possible base alloys - see list below
 - Analyzer applies the Tramp Grade/base specific tramp limits from the matching Tramp Grade;
2. These "Tramp Limits" or "alloy base specific" limits are applied when an element is detected in a specific grade.
 - But, the nearest grade match has no specification for that element,
 - And, the concentration of the sample is less than the max limit specified by the matching Tramp Grade.
3. When conditions of #2 are met, the element is reported on the User Interface screen.
 - In **blue**;
 - Is labeled as a **"Tramp"** material in the grade comparison table;
 - But the grade match is not penalized.

PRACTICAL ADVANTAGES
of this "tramp element"
approach:

- Faster sorting,
- Fewer ambiguous or incorrect matches,
- Improved grade library integrity,
- Prominent labeling of tramp elements.

TRAMP Library Base Alloys

_AlAlloyBase

Common Tramp Elements: Pb, Bi, Sn, Fe, Cu, Zn

_CoAlloyBase

Common Tramp Elements: Al, Ti, V, Cu, Nb, Ta, Zr

_CuAlloyBase

Common Tramp Elements: S, As, Ag, Sb, Sn; not as common Pb, Co, Ni

_FeAlloyBase

Common Tramp Elements: V, Co, Cu, Ni, As - sometimes Si, W, Nb

_GenericAlloyBase

Common Tramp Elements: V, Co, Cu, Ni, As - sometimes Si, W, Nb

_NiAlloyBase

Common Tramp Elements: V, Co, W, Zr, Nb - sometimes Ta, Mo, Cr, Cu

_TiAlloyBase

Common Tramp Elements: Fe is common, Cu & Si show up at low levels.

Factory Grade Library {Table A9.1-Classic}

Aluminums- C	Cobalt Alloys - C	Specialty Grades- C	Copper Alloys -C		
2007 2011 2018 2117 2618 4032 5454 6040 6061 6070 6253 6262 7005 7016 7019 7039 7050 7072 7075 7104 1100-plus 2024-plus 2098-2195 2219-2519 3003 or 4 or 5 355-2 5052-plus 5086-plus 6063-plus 7049-149-249	Alloy 686 AlnicoVIII Cobalt Elgiloy F75 FSX-414 Haynes188 Haynes36 HS-1 HS-12 HS-19 HS-21 HS25-L605 HS-31 HS-4 HS-6B Jetalloy MarM302 MarM509 MarM905 MP35N MPN159 Star J Ultimet	60Sn-40Pb 63Sn-37Pb 96-4 AZ31B AZ91A or C SAC 300 SAC 305 SAC 400 SAC 405 97-3 Ag Au Bi Cb 103 CP Ta Cr Densalloy Hf Mn Mo Nb Ni Pb Pd Re Sb Se Sn TungCarb C TungCarb S V W Zn Zr Zr 2 or 4 Zr 702 Zr 704 Zr 705	C 110 C 172 C 194 C 210 C 220 C 260 C 270 C 310 C 314 C 330 C 332 C 340 C 342 C 360 C 377 C 425 C 443 C 464 C 482 C 485	C 510 C 524 C 534 C 544 C 623 C 630 C 655 C 667 C 673 C 675 C 706 C 710 C 715 C 745 C 752 C 814 C 836 C 857	C 864 C 867 C 868 C 875 C 8932 C 903 C 922 C 932 C 937 C 955 C194HiCu C197HiCu Elec Cu Muntz NarloyZ SeBiLOYI SeBiLOYII SeBiLOYIII
Low Alloy Steels-C	Chrome- Moly Steels -C	Nickel Alloys - C			
3310 4130 4140 4340 8620 9310 12L14 A10 Carb 1-2 Moly Carbon Steel 20Mo4	1 1-4 Cr 2 1-4 Cr 5 Cr 9 Cr P91	B 1900 B-1900 Hf C-1023 GMR235 GTD222 Hast BC1 HastB HastB2 HastB3 HastC2000 HastC22 HastC276 HastC4 HastF HastG HastG2 HastG3 HastG30 HastN HastR HastS HastW HastX Haynes230 HR160 HyMu80 I-102I-49 I-600 I-601	I-617 I-625 I-690 I-700 I-702 I-706 I-713 I-718 I-720 I-722 I-725 I-738 I-750 I-792 I-800 I-801 I-825 I-901 I-903 I-907-909 I-939 IN100Mar M002 MarM200 MarM246 MarM247	MarM421 Monel400 Monel411 MonelK500 MuMetal Ni 200 NichromeV Nim101 Nim263 Nimonic75 Nimonic80A Nimonic90 PWA1480 PWA1484 RA333 Rene125 Rene142 Rene220 Rene41 Rene77 Rene80 Rene95 Supertherm Udimet500 Udimet520 Udimet700 Waspaloy	

Factory Grade Library {Table A9.2-Classic}

Stainless Grades - C		
201	21-6-9	Haynes556
203	25-4-4	Incoloy840
304	254SMO	Invar 36
309	26-1	Kovar
310	29-4	M152
316	29-4-2	Maraging35
317	29-4C	0
321	302HQ	MaragingC2
329	410 Cb	00
330	410-16-20	MaragingC2
347	904L	50
422	A-286	MaragingC3
430	AL6XN	00
431	Alloy42	N-155
434	Alnicoll	Ni-hard#1
440	Alnicoll	Ni-hard#4
441	AlnicoV	Ni-Span902
446	AMS350	Nitronic40
2003	AMS355	Nitronic50
2101	CD4MCU	Nitronic60
2507	Custom450	RA330
13-8 Mo	Custom455	RA85H
15-5 PH	Duplex2205	Zeron100
15Mn7Cr	E-bite	
17-4 PH	Ferallium25	
17-7 PH	5	
19-9DL	GreekAs-	
19-9DX	coloy	
20Cb3	H12	
20Mo6	H13	

Ti Grades - C
Cp Ti
Cp Ti Pd
Ti 12
Ti 17
Ti 3 2-5
Ti 6-22-22
Ti 6-2-4-2
Ti 6-2-4-6
Ti 6-4
Ti 6-6-2
Ti 8
Ti 8-1-1
Ti10-2-3
Ti15-3-3-3
Ti3-11-13
Ti5 - 2-5
Ti6-2-1-1
TiBetaC

Tool Steels- C
A2
A6
A7
D2 or D4
D7
H-11
M1
M2
M4
M42
O1
O2
O6
O7
S1
S5
S6
S7
T1

Delta CLASSIC

Factory Grade Library {Table A9.3-Standard}

Delta STANDARD

Aluminums-S	Cobalt Alloys - S	Specialty Grades- S	Copper Alloys -S		
319	Alloy 686	60Sn-40Pb	C 110	C 510	C 864
333	AlnicoVIII	63Sn-37Pb	C 172	C 524	C 867
380	Cobalt	96-4	C 194	C 534	C 868
383	Elgiloy	AZ31B	C 210	C 544	C 875
384	F75	AZ91A or C	C 220	C 623	C 8932
2007	FSX-414	SAC 300	C 260	C 630	C 903
2011	Haynes188	SAC 305	C 270	C 655	C 922
2018	Haynes36	SAC 400	C 310	C 667	C 932
2024	HS-1	SAC 405	C 314	C 673	C 937
2117	HS-12	97-3	C 330	C 675	C 955
2618	HS-19	Ag	C 332	C 706	C194HiCu
3004	HS-21	Au	C 340	C 710	C197HiCu
4032	HS25-L605	Bi	C 342	C 715	Elec Cu
5042	HS-31	Cb 103	C 360	C 745	Muntz
5052	HS-4	CP Ta	C 377	C 752	NarloyZ
5083	HS-6B	Cr	C 425	C 814	SeBiLOYI
5086	Jetalloy	Densalloy	C 443	C 836	SeBiLOYII
5154	MarM302	Hf	C 464	C 857	SeBiLOYIII
5454	MarM509	Mn	C 482		
6040	MarM905	Mo	C 485		
6061	MP35N	Nb			
6070	MPN159	Ni			
6253	Star J	Pb			
6262	Ultimet	Pd			
7005		Re			
7016		Sb			
7019		Se			
7039		Sn			
7050		TungCarb C			
7072		TungCarb S			
7075		V			
7104		W			
1100-plus		Zn			
2014-17 std		Zr			
2024-plus		Zr 2 or 4			
2098-2195		Zr 702			
2219-2519		Zr 704			
3003 or 4 or 5		Zr 705			
3003 or 5					
355-2					
356-57-std					
5052-plus					
5056-82					
5086-plus					
6063-plus					
7049-149-249					
	Low Alloy Steels-S	Chrome-Moly Steels -S	Nickel Alloys - S		
	3310	1 1-4 Cr	20Mo4	I-102	MarM247
	4130	2 1-4 Cr	B 1900	I-49	MarM421
	4140	5 Cr	B-1900 Hf	I-600	Monel400
	4340	9 Cr	C-1023	I-601	Monel411
	8620	P91	Colmonoy	I-602	MonelK500
	9310		6	I-617	MuMetal
	12L14		GMR235	I-625	Ni 200
	A10		GTD222	I-690	NichromeV
	Carb 1-2		Hast BC1	I-700	Nim101
	Moly		HastB	I-702	Nim263
	Carbon Steel		HastB2	I-706	Nimonic75
	P20		HastB3	I-713	Nimonic80A
	135 N		HastC2000	I-718	Nimonic90
			HastC22	I-720	PWA1480
			HastC276	I-722	PWA1484
			HastC4	I-725	RA333
			HastF	I-738	Rene125
			HastG	I-750	Rene142
			HastG2	I-792	Rene220
			HastG3	I-800	Rene41
			HastG30	I-801	Rene77
			HastN	I-825	Rene80
			HastR	I-901	Rene95
			HastS	I-903	Supertherm
			HastW	I-907-909	Udimet500
			HastX	I-939	Udimet520
			Haynes214	IN100	Udimet700
			Haynes230	MarM002	Waspaloy
			HR160	MarM200	
			HyMu80	MarM246	

Factory Grade Library {Table A9.4-Standard}

Stainless Grades - S			Ti Grades - S		Tool Steels- S	
201	17-4 PH	H12	Cp Ti		A2	
203	17-7 PH	H13	Cp Ti Pd		A6	
303	19-9DL	Haynes556	Ti 12		A7	
304	19-9DX	Incoloy840	Ti 17		D2 or D4	
309	20Cb3	Invar 36	Ti 3 2-5		D7	
310	20Mo6	Kovar	Ti 6-22-22		H-11	
316		M152	Ti 6-2-4-2		M1	
317	21-6-9	Maraging350	Ti 6-2-4-6		M2	
321	25-4-4	MaragingC200	Ti 6-4		M4	
329	254SMO	MaragingC250	Ti 6-6-2		M42	
330	26-1	MaragingC300	Ti 8		O1	
347	29-4		Ti 8-1-1		O2	
410	29-4-2	N-155	Ti10-2-3		O6	
416	29-4C	Ni-hard#1	Ti15-3-3-3		O7	
420	302HQ	Ni-hard#4	Ti3-11-13		S1	
422	410 Cb	Ni-Span902	Ti5 - 2-5		S5	
430	410-16-20	Nitronic40	Ti6-2-1-1		S6	
431	904L	Nitronic50	TiBetaC		S7	
434	A-286	Nitronic60			T1	
440	AL6XN	RA330				
441	Alloy42	RA85H				
446	AlnicoII	Zeron100				
2003	AlnicoIII					
2101	AlnicoV					
2205	AMS350					
2205	AMS355					
2507	CD4MCU					
13-8 Mo	Custom450					
15-5 PH	Custom455					
15Mn7Cr	E-bite					
	Ferallium255					
	GreekAscoloy					


Factory Grade Library {Table A9.6-Premium}

Stainless Grades - P		
201	17-4 PH	H12
203	17-7 PH	H13
303	19-9DL	Haynes556
304	19-9DX	Incoloy840
309	20Cb3	Invar 36
310	20Mo6	Kovar
316	21-6-9	M152
317	25-4-4	Maraging350
321	254SMO	MaragingC200
329	26-1	MaragingC250
330	29-4	MaragingC300
347	29-4-2	N-155
410	29-4C	Ni-hard#1
416	302HQ	Ni-hard#4
420	410 Cb	Ni-Span902
422	410-16-20	Nitronic40
430	904L	Nitronic50
431	A-286	Nitronic60
434	AL6XN	RA330
440	Alloy42	RA85H
441	Alnicoll	Zeron100
446	Alnicoll	
2003	AlnicoV	
2101	AMS350	
2205	AMS355	
2205	CD4MCU	
2507	Custom450	
13-8 Mo	Custom455	
15-5 PH	E-bite	
15Mn7Cr	Ferallium255	
	GreekAscology	

Ti Grades - P
Cp Ti
Cp Ti Pd
Ti 12
Ti 17
Ti 3 2-5
Ti 6-22-22
Ti 6-2-4-2
Ti 6-2-4-6
Ti 6-4
Ti 6-6-2
Ti 8
Ti 8-1-1
Ti10-2-3
Ti15-3-3-3
Ti3-11-13
Ti5 - 2-5
Ti6-2-1-1
TiBetaC

Tool Steels- P
A2
A6
A7
D2 or D4
D7
H-11
M1
M2
M4
M42
O1
O2
O6
O7
S1
S5
S6
S7
T1

Delta PREMIUM

	GO TO
	<ul style="list-style-type: none">• See “Delta User Interface Guide” (PN 103202) for a complete description for using Alloy modes’ new capabilities such as:<ul style="list-style-type: none">— Grade Match Messaging,— SmartSorting,— Nominal Chemistry, and— Tramp Library management.

DELTA HHXRF Analyzers

Limits of Detection (LODs)



LODs, reported in PPM unless otherwise noted, are optimal. Measurements were taken in air for 120 seconds per beam. Standards used were in a clean, homogenous SiO₂ matrix without interfering elements.

Limits of detection for handheld XRF instrumentation are typically determined using well defined and easily reproduced parameters:

Optimized hardware settings

- > X-ray tube target material
- > Power (kV, μ A)
- > Filters
- > Background subtraction and/or normalization

Measurement times

- > 60 to 120 seconds depending on the element of interest

Interference-free standards

- > Standards used to determine instrumentation detection limits typically do not contain anything that introduces other variables, such as interfering elements, unless the hardware settings used eliminate or significantly reduce the interference.

The determination of detection limits for all methods of analysis depend on numerous factors including the instrumentation and its settings, the standards that are utilized to determine the limits of detection, and the actual working samples analyzed.

LODs reported here are based on Innov-X's DELTA Premium, with two different anode configurations, and DELTA Classic;; automatically selected kV- μ A-Filter settings; SiO₂ blank measurements; Compton normalization; 120 seconds measurement time; standards that are pure elemental oxides, and NIST standards with some common soil matrices. All measurements were done in air (not under vacuum).

These parameters allow the determination of the best LODs for the handheld XRF being calibrated. Actual working samples may contain interfering elements that the hardware settings or selection of analyte lines do not correct for; therefore, the actual working LODs for "real-world" samples may be higher than those determined with the interference-free standards.

Element of Interest	DELTA Premium	DELTA Premium	DELTA Classic
	3-Beam Soil	3-B Soil & 2-B Mining	3-Beam Soil
	Ta/Au Tube, SDD	Rh Tube, SDD	Au Tube, SiPiN
Mg	Not Available	< 1%	Not Available
Al	Not Available	< 0.5%	Not Available
Si	Not Available	< 0.5%	Not Available
P	500 - 700	800 - 1500	1 - 5%
S	100 - 250	150 - 300	0.1 - 0.5%
Cl	60 - 100	100 - 200	500 - 1000
K	30 - 50	40 - 60	150 - 250
Ca	20 - 30	25 - 40	150 - 250
Ti	7 - 15	7 - 15	20 - 50
Cr	5 - 10	5 - 10	10 - 30
V	7 - 15	7 - 15	10 - 30
Mn	3 - 5	10	10 - 30
Fe	5	10	10 - 30
Co	10 - 20	10 - 20	20 - 40
Ni	10 - 20	10 - 20	20 - 40
Cu	5 - 7	5 - 7	15 - 30
Zn	3 - 5	3 - 5	10 - 15
Ga	3 - 5	3 - 5	10 - 15
As	1 - 3	1 - 3	4 - 8
Se	1 - 3	1 - 3	4 - 8
Br	1 - 3	1 - 3	4 - 8
Rb	1	1 - 3	3 - 5
Sr	1	1 - 3	3 - 5
Zr	1	1 - 3	3 - 5
Mo	1	1 - 3	3 - 5
Ag	6 - 8	40 - 50	20 - 30
Cd	6 - 8	12 - 15	20 - 30
Sn	11 - 15	20 - 25	30 - 40
Sb	12 - 15	15 - 20	30 - 40
Ba	10 - 20	15 - 30	40 - 60
Hg	2 - 4	2 - 4	10 - 15
Tl	2 - 4	2 - 4	10 - 15
Pb	2 - 4	2 - 4	5 - 10



NOTE:

Common, well-known interelement interferences for environmental real-world soil samples are as follows:

- » High levels of Fe can interfere with low levels of Cr
- » High levels of Ti can interfere with low levels of Ba
- » High levels of Pb can interfere with low levels of As

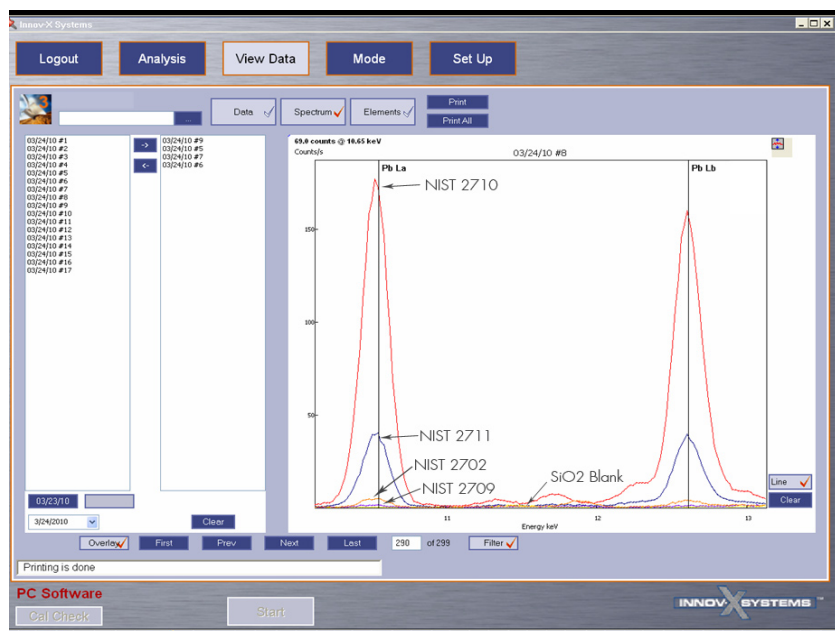


LIMITS OF DETECTION

Accuracy and precision are important factors with all analysis techniques. Accuracy describes how well the measured results agree with the certified results. Precision describes how reproducible the measured results are. The following data show accuracy and precision results for Lead (Pb) measurements using the DELTA.



A DELTA handheld XRF analyzer, configured in SmartShot Soil analysis mode, was used to measure Lead (Pb) in four NIST soil matrix standards and a blank. As shown below, analysis spectra can be easily overlaid and compared using the Delta PC Software. Here the user has zoomed in on the Pb La and Lb peaks for direct comparison.



Analysis results for the NIST standards are shown at right.

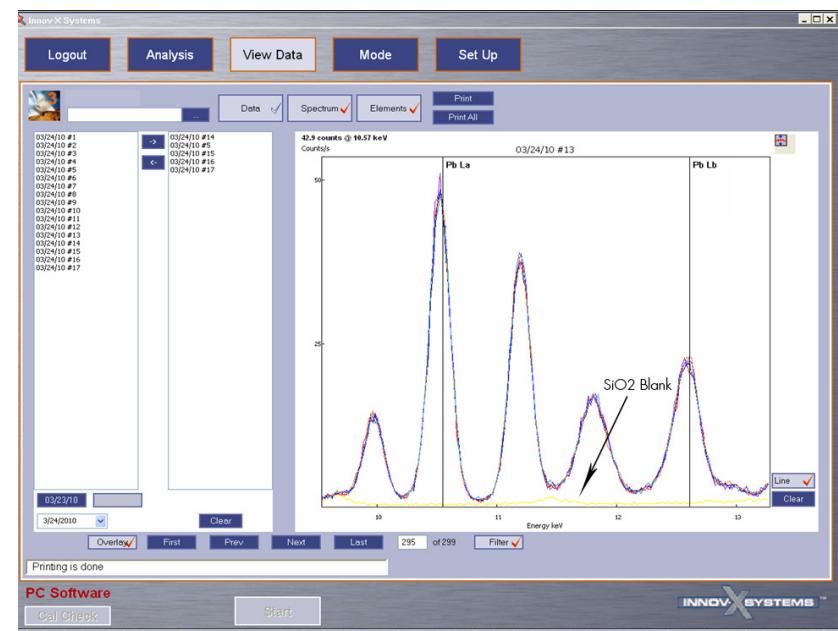
A 60 second measurement time was used.

Results shown in ppm

+/- error shown is 2-sigma, 95% confidence.

NIST Std	Pb Value Given	Pb Value Measured	+/- Measured
SiO ₂ Blank	0	<2	-
NIST 2702	132.8	135	4
NIST 2709	18.9	20.2	1.9
NIST 2710	5525	5587	39
NIST 2711	1162	1158	11

A DELTA handheld XRF analyzer, configured in SmartShot soil analysis mode, was used to run repeat measurements on a reference soil sample, to demonstrate repeatability. As shown below, the DELTA PC Software can be used to overlay spectra from different readings for direct comparison and analysis.



A reference sample spiked with approximately 500ppm Pb (Innov-X sample 408) was used for these repeat readings.

Each reading was analyzed for 60 seconds.

+/- error shown is 2-sigma, 95% confidence.

Sample Run	Pb ppm Value	+/-
1	511	7
2	512	7
3	514	7
4	521	7
5	514	7
Avg	514	7

METHOD 6200

FIELD PORTABLE X-RAY FLUORESCENCE SPECTROMETRY FOR THE DETERMINATION OF ELEMENTAL CONCENTRATIONS IN SOIL AND SEDIMENT

SW-846 is not intended to be an analytical training manual. Therefore, method procedures are written based on the assumption that they will be performed by analysts who are formally trained in at least the basic principles of chemical analysis and in the use of the subject technology.

In addition, SW-846 methods, with the exception of required method use for the analysis of method-defined parameters, are intended to be guidance methods which contain general information on how to perform an analytical procedure or technique which a laboratory can use as a basic starting point for generating its own detailed Standard Operating Procedure (SOP), either for its own general use or for a specific project application. The performance data included in this method are for guidance purposes only, and are not intended to be and must not be used as absolute QC acceptance criteria for purposes of laboratory accreditation.

1.0 SCOPE AND APPLICATION

1.1 This method is applicable to the in situ and intrusive analysis of the 26 analytes listed below for soil and sediment samples. Some common elements are not listed in this method because they are considered "light" elements that cannot be detected by field portable x-ray fluorescence (FPXRF). These light elements are: lithium, beryllium, sodium, magnesium, aluminum, silicon, and phosphorus. Most of the analytes listed below are of environmental concern, while a few others have interference effects or change the elemental composition of the matrix, affecting quantitation of the analytes of interest. Generally elements of atomic number 16 or greater can be detected and quantitated by FPXRF. The following RCRA analytes have been determined by this method:

Analytes	CAS Registry No.
Antimony (Sb)	7440-36-0
Arsenic (As)	7440-38-0
Barium (Ba)	7440-39-3
Cadmium (Cd)	7440-43-9
Chromium (Cr)	7440-47-3
Cobalt (Co)	7440-48-4
Copper (Cu)	7440-50-8
Lead (Pb)	7439-92-1
Mercury (Hg)	7439-97-6
Nickel (Ni)	7440-02-0
Selenium (Se)	7782-49-2
Silver (Ag)	7440-22-4
Thallium (Tl)	7440-28-0
Tin (Sn)	7440-31-5

Analytes	CAS Registry No.
Vanadium (V)	7440-62-2
Zinc (Zn)	7440-66-6

In addition, the following non-RCRA analytes have been determined by this method:

Analytes	CAS Registry No.
Calcium (Ca)	7440-70-2
Iron (Fe)	7439-89-6
Manganese (Mn)	7439-96-5
Molybdenum (Mo)	7439-93-7
Potassium (K)	7440-09-7
Rubidium (Rb)	7440-17-7
Strontium (Sr)	7440-24-6
Thorium (Th)	7440-29-1
Titanium (Ti)	7440-32-6
Zirconium (Zr)	7440-67-7

1.2 This method is a screening method to be used with confirmatory analysis using other techniques (e.g., flame atomic absorption spectrometry (FLAA), graphite furnace atomic absorption spectrometry (GFAA), inductively coupled plasma-atomic emission spectrometry, (ICP-AES), or inductively coupled plasma-mass spectrometry, (ICP-MS)). This method's main strength is that it is a rapid field screening procedure. The method's lower limits of detection are typically above the toxicity characteristic regulatory level for most RCRA analytes. However, when the obtainable values for precision, accuracy, and laboratory-established sensitivity of this method meet project-specific data quality objectives (DQOs), FPXRF is a fast, powerful, cost effective technology for site characterization.

1.3 The method sensitivity or lower limit of detection depends on several factors, including the analyte of interest, the type of detector used, the type of excitation source, the strength of the excitation source, count times used to irradiate the sample, physical matrix effects, chemical matrix effects, and interelement spectral interferences. Example lower limits of detection for analytes of interest in environmental applications are shown in Table 1. These limits apply to a clean spiked matrix of quartz sand (silicon dioxide) free of interelement spectral interferences using long (100 -600 second) count times. These sensitivity values are given for guidance only and may not always be achievable, since they will vary depending on the sample matrix, which instrument is used, and operating conditions. A discussion of performance-based sensitivity is presented in Sec. 9.6.

1.4 Analysts should consult the disclaimer statement at the front of the manual and the information in Chapter Two for guidance on the intended flexibility in the choice of methods, apparatus, materials, reagents, and supplies, and on the responsibilities of the analyst for demonstrating that the techniques employed are appropriate for the analytes of interest, in the matrix of interest, and at the levels of concern.

In addition, analysts and data users are advised that, except where explicitly specified in a regulation, the use of SW-846 methods is *not* mandatory in response to Federal testing requirements. The information contained in this method is provided by EPA as guidance to be used by the analyst and the regulated community in making judgments necessary to generate results that meet the data quality objectives for the intended application.

1.5 Use of this method is restricted to use by, or under supervision of, personnel appropriately experienced and trained in the use and operation of an XRF instrument. Each analyst must demonstrate the ability to generate acceptable results with this method.

2.0 SUMMARY OF METHOD

2.1 The FPXRF technologies described in this method use either sealed radioisotope sources or x-ray tubes to irradiate samples with x-rays. When a sample is irradiated with x-rays, the source x-rays may undergo either scattering or absorption by sample atoms. This latter process is known as the photoelectric effect. When an atom absorbs the source x-rays, the incident radiation dislodges electrons from the innermost shells of the atom, creating vacancies. The electron vacancies are filled by electrons cascading in from outer electron shells. Electrons in outer shells have higher energy states than inner shell electrons, and the outer shell electrons give off energy as they cascade down into the inner shell vacancies. This rearrangement of electrons results in emission of x-rays characteristic of the given atom. The emission of x-rays, in this manner, is termed x-ray fluorescence.

Three electron shells are generally involved in emission of x-rays during FPXRF analysis of environmental samples. The three electron shells include the K, L, and M shells. A typical emission pattern, also called an emission spectrum, for a given metal has multiple intensity peaks generated from the emission of K, L, or M shell electrons. The most commonly measured x-ray emissions are from the K and L shells; only metals with an atomic number greater than 57 have measurable M shell emissions.

Each characteristic x-ray line is defined with the letter K, L, or M, which signifies which shell had the original vacancy and by a subscript alpha (α), beta (β), or gamma (γ) etc., which indicates the higher shell from which electrons fell to fill the vacancy and produce the x-ray. For example, a K_α line is produced by a vacancy in the K shell filled by an L shell electron, whereas a K_β line is produced by a vacancy in the K shell filled by an M shell electron. The K_α transition is on average 6 to 7 times more probable than the K_β transition; therefore, the K_α line is approximately 7 times more intense than the K_β line for a given element, making the K_α line the choice for quantitation purposes.

The K lines for a given element are the most energetic lines and are the preferred lines for analysis. For a given atom, the x-rays emitted from L transitions are always less energetic than those emitted from K transitions. Unlike the K lines, the main L emission lines (L_α and L_β) for an element are of nearly equal intensity. The choice of one or the other depends on what interfering element lines might be present. The L emission lines are useful for analyses involving elements of atomic number (Z) 58 (cerium) through 92 (uranium).

An x-ray source can excite characteristic x-rays from an element only if the source energy is greater than the absorption edge energy for the particular line group of the element, that is, the K absorption edge, L absorption edge, or M absorption edge energy. The absorption edge energy is somewhat greater than the corresponding line energy. Actually, the K absorption edge energy is approximately the sum of the K, L, and M line energies of the particular element, and the L absorption edge energy is approximately the sum of the L and M line energies. FPXRF is more sensitive to an element with an absorption edge energy close to but less than

the excitation energy of the source. For example, when using a cadmium-109 source, which has an excitation energy of 22.1 kiloelectron volts (keV), FPXRF would exhibit better sensitivity for zirconium which has a K line energy of 15.77 keV than to chromium, which has a K line energy of 5.41 keV.

2.2 Under this method, inorganic analytes of interest are identified and quantitated using a field portable energy-dispersive x-ray fluorescence spectrometer. Radiation from one or more radioisotope sources or an electrically excited x-ray tube is used to generate characteristic x-ray emissions from elements in a sample. Up to three sources may be used to irradiate a sample. Each source emits a specific set of primary x-rays that excite a corresponding range of elements in a sample. When more than one source can excite the element of interest, the source is selected according to its excitation efficiency for the element of interest.

For measurement, the sample is positioned in front of the probe window. This can be done in two manners using FPXRF instruments, specifically, in situ or intrusive. If operated in the in situ mode, the probe window is placed in direct contact with the soil surface to be analyzed. When an FPXRF instrument is operated in the intrusive mode, a soil or sediment sample must be collected, prepared, and placed in a sample cup. The sample cup is then placed on top of the window inside a protective cover for analysis.

Sample analysis is then initiated by exposing the sample to primary radiation from the source. Fluorescent and backscattered x-rays from the sample enter through the detector window and are converted into electric pulses in the detector. The detector in FPXRF instruments is usually either a solid-state detector or a gas-filled proportional counter. Within the detector, energies of the characteristic x-rays are converted into a train of electric pulses, the amplitudes of which are linearly proportional to the energy of the x-rays. An electronic multichannel analyzer (MCA) measures the pulse amplitudes, which is the basis of qualitative x-ray analysis. The number of counts at a given energy per unit of time is representative of the element concentration in a sample and is the basis for quantitative analysis. Most FPXRF instruments are menu-driven from software built into the units or from personal computers (PC).

The measurement time of each source is user-selectable. Shorter source measurement times (30 seconds) are generally used for initial screening and hot spot delineation, and longer measurement times (up to 300 seconds) are typically used to meet higher precision and accuracy requirements.

FPXRF instruments can be calibrated using the following methods: internally using fundamental parameters determined by the manufacturer, empirically based on site-specific calibration standards (SSCS), or based on Compton peak ratios. The Compton peak is produced by backscattering of the source radiation. Some FPXRF instruments can be calibrated using multiple methods.

3.0 DEFINITIONS

3.1 FPXRF -- Field portable x-ray fluorescence.

3.2 MCA -- Multichannel analyzer for measuring pulse amplitude.

3.3 SSCS -- Site-specific calibration standards.

3.4 FP -- Fundamental parameter.

3.5 ROI -- Region of interest.

3.6 SRM -- Standard reference material; a standard containing certified amounts of metals in soil or sediment.

3.7 eV -- Electron volt; a unit of energy equivalent to the amount of energy gained by an electron passing through a potential difference of one volt.

3.8 Refer to Chapter One, Chapter Three, and the manufacturer's instructions for other definitions that may be relevant to this procedure.

4.0 INTERFERENCES

4.1 The total method error for FPXRF analysis is defined as the square root of the sum of squares of both instrument precision and user- or application-related error. Generally, instrument precision is the least significant source of error in FPXRF analysis. User- or application-related error is generally more significant and varies with each site and method used. Some sources of interference can be minimized or controlled by the instrument operator, but others cannot. Common sources of user- or application-related error are discussed below.

4.2 Physical matrix effects result from variations in the physical character of the sample. These variations may include such parameters as particle size, uniformity, homogeneity, and surface condition. For example, if any analyte exists in the form of very fine particles in a coarser-grained matrix, the analyte's concentration measured by the FPXRF will vary depending on how fine particles are distributed within the coarser-grained matrix. If the fine particles "settle" to the bottom of the sample cup (i.e., against the cup window), the analyte concentration measurement will be higher than if the fine particles are not mixed in well and stay on top of the coarser-grained particles in the sample cup. One way to reduce such error is to grind and sieve all soil samples to a uniform particle size thus reducing sample-to-sample particle size variability. Homogeneity is always a concern when dealing with soil samples. Every effort should be made to thoroughly mix and homogenize soil samples before analysis. Field studies have shown heterogeneity of the sample generally has the largest impact on comparability with confirmatory samples.

4.3 Moisture content may affect the accuracy of analysis of soil and sediment sample analyses. When the moisture content is between 5 and 20 percent, the overall error from moisture may be minimal. However, moisture content may be a major source of error when analyzing samples of surface soil or sediment that are saturated with water. This error can be minimized by drying the samples in a convection or toaster oven. Microwave drying is not recommended because field studies have shown that microwave drying can increase variability between FPXRF data and confirmatory analysis and because metal fragments in the sample can cause arcing to occur in a microwave.

4.4 Inconsistent positioning of samples in front of the probe window is a potential source of error because the x-ray signal decreases as the distance from the radioactive source increases. This error is minimized by maintaining the same distance between the window and each sample. For the best results, the window of the probe should be in direct contact with the sample, which means that the sample should be flat and smooth to provide a good contact surface.

4.5 Chemical matrix effects result from differences in the concentrations of interfering elements. These effects occur as either spectral interferences (peak overlaps) or as x-ray absorption and enhancement phenomena. Both effects are common in soils contaminated with heavy metals. As examples of absorption and enhancement effects; iron (Fe) tends to absorb copper (Cu) x-rays, reducing the intensity of the Cu measured by the detector, while chromium (Cr) will be enhanced at the expense of Fe because the absorption edge of Cr is slightly lower in energy than the fluorescent peak of iron. The effects can be corrected mathematically through the use of fundamental parameter (FP) coefficients. The effects also can be compensated for using SSCS, which contain all the elements present on site that can interfere with one another.

4.6 When present in a sample, certain x-ray lines from different elements can be very close in energy and, therefore, can cause interference by producing a severely overlapped spectrum. The degree to which a detector can resolve the two different peaks depends on the energy resolution of the detector. If the energy difference between the two peaks in electron volts is less than the resolution of the detector in electron volts, then the detector will not be able to fully resolve the peaks.

The most common spectrum overlaps involve the K_{β} line of element Z-1 with the K_{α} line of element Z. This is called the K_{α}/K_{β} interference. Because the $K_{\alpha}:K_{\beta}$ intensity ratio for a given element usually is about 7:1, the interfering element, Z-1, must be present at large concentrations to cause a problem. Two examples of this type of spectral interference involve the presence of large concentrations of vanadium (V) when attempting to measure Cr or the presence of large concentrations of Fe when attempting to measure cobalt (Co). The V K_{α} and K_{β} energies are 4.95 and 5.43 keV, respectively, and the Cr K_{α} energy is 5.41 keV. The Fe K_{α} and K_{β} energies are 6.40 and 7.06 keV, respectively, and the Co K_{α} energy is 6.92 keV. The difference between the V K_{β} and Cr K_{α} energies is 20 eV, and the difference between the Fe K_{β} and the Co K_{α} energies is 140 eV. The resolution of the highest-resolution detectors in FPXRF instruments is 170 eV. Therefore, large amounts of V and Fe will interfere with quantitation of Cr or Co, respectively. The presence of Fe is a frequent problem because it is often found in soils at tens of thousands of parts per million (ppm).

4.7 Other interferences can arise from K/L, K/M, and L/M line overlaps, although these overlaps are less common. Examples of such overlap involve arsenic (As) K_{α} /lead (Pb) L_{α} and sulfur (S) K_{α} /Pb M_{α} . In the As/Pb case, Pb can be measured from the Pb L_{β} line, and As can be measured from either the As K_{α} or the As K_{β} line; in this way the interference can be corrected. If the As K_{β} line is used, sensitivity will be decreased by a factor of two to five times because it is a less intense line than the As K_{α} line. If the As K_{α} line is used in the presence of Pb, mathematical corrections within the instrument software can be used to subtract out the Pb interference. However, because of the limits of mathematical corrections, As concentrations cannot be efficiently calculated for samples with Pb:As ratios of 10:1 or more. This high ratio of Pb to As may result in reporting of a "nondetect" or a "less than" value (e.g., <300 ppm) for As, regardless of the actual concentration present.

No instrument can fully compensate for this interference. It is important for an operator to understand this limitation of FPXRF instruments and consult with the manufacturer of the FPXRF instrument to evaluate options to minimize this limitation. The operator's decision will be based on action levels for metals in soil established for the site, matrix effects, capabilities of the instrument, data quality objectives, and the ratio of lead to arsenic known to be present at the site. If a site is encountered that contains lead at concentrations greater than ten times the concentration of arsenic it is advisable that all critical soil samples be sent off site for confirmatory analysis using other techniques (e.g., flame atomic absorption spectrometry (FLAA), graphite furnace atomic absorption spectrometry (GFAA), inductively coupled plasma-

atomic emission spectrometry, (ICP-AES), or inductively coupled plasma-mass spectrometry, (ICP-MS)).

4.8 If SSCS are used to calibrate an FPXRF instrument, the samples collected must be representative of the site under investigation. Representative soil sampling ensures that a sample or group of samples accurately reflects the concentrations of the contaminants of concern at a given time and location. Analytical results for representative samples reflect variations in the presence and concentration ranges of contaminants throughout a site. Variables affecting sample representativeness include differences in soil type, contaminant concentration variability, sample collection and preparation variability, and analytical variability, all of which should be minimized as much as possible.

4.9 Soil physical and chemical effects may be corrected using SSCS that have been analyzed by inductively coupled plasma (ICP) or atomic absorption (AA) methods. However, a major source of error can be introduced if these samples are not representative of the site or if the analytical error is large. Another concern is the type of digestion procedure used to prepare the soil samples for the reference analysis. Analytical results for the confirmatory method will vary depending on whether a partial digestion procedure, such as Method 3050, or a total digestion procedure, such as Method 3052, is used. It is known that depending on the nature of the soil or sediment, Method 3050 will achieve differing extraction efficiencies for different analytes of interest. The confirmatory method should meet the project-specific data quality objectives (DQOs).

XRF measures the total concentration of an element; therefore, to achieve the greatest comparability of this method with the reference method (reduced bias), a total digestion procedure should be used for sample preparation. However, in the study used to generate the performance data for this method (see Table 8), the confirmatory method used was Method 3050, and the FPXRF data compared very well with regression correlation coefficients (r often exceeding 0.95, except for barium and chromium). The critical factor is that the digestion procedure and analytical reference method used should meet the DQOs of the project and match the method used for confirmation analysis.

4.10 Ambient temperature changes can affect the gain of the amplifiers producing instrument drift. Gain or drift is primarily a function of the electronics (amplifier or preamplifier) and not the detector as most instrument detectors are cooled to a constant temperature. Most FPXRF instruments have a built-in automatic gain control. If the automatic gain control is allowed to make periodic adjustments, the instrument will compensate for the influence of temperature changes on its energy scale. If the FPXRF instrument has an automatic gain control function, the operator will not have to adjust the instrument's gain unless an error message appears. If an error message appears, the operator should follow the manufacturer's procedures for troubleshooting the problem. Often, this involves performing a new energy calibration. The performance of an energy calibration check to assess drift is a quality control measure discussed in Sec. 9.2.

If the operator is instructed by the manufacturer to manually conduct a gain check because of increasing or decreasing ambient temperature, it is standard to perform a gain check after every 10 to 20 sample measurements or once an hour whichever is more frequent. It is also suggested that a gain check be performed if the temperature fluctuates more than 10° F. The operator should follow the manufacturer's recommendations for gain check frequency.

5.0 SAFETY

5.1 This method does not address all safety issues associated with its use. The user is responsible for maintaining a safe work environment and a current awareness file of OSHA regulations regarding the safe handling of the chemicals listed in this method. A reference file of material safety data sheets (MSDSs) should be available to all personnel involved in these analyses.

NOTE: No MSDS applies directly to the radiation-producing instrument because that is covered under the Nuclear Regulatory Commission (NRC) or applicable state regulations.

5.2 Proper training for the safe operation of the instrument and radiation training should be completed by the analyst prior to analysis. Radiation safety for each specific instrument can be found in the operator's manual. Protective shielding should never be removed by the analyst or any personnel other than the manufacturer. The analyst should be aware of the local state and national regulations that pertain to the use of radiation-producing equipment and radioactive materials with which compliance is required. There should be a person appointed within the organization that is solely responsible for properly instructing all personnel, maintaining inspection records, and monitoring x-ray equipment at regular intervals.

Licenses for radioactive materials are of two types, specifically: (1) a general license which is usually initiated by the manufacturer for receiving, acquiring, owning, possessing, using, and transferring radioactive material incorporated in a device or equipment, and (2) a specific license which is issued to named persons for the operation of radioactive instruments as required by local, state, or federal agencies. A copy of the radioactive material license (for specific licenses only) and leak tests should be present with the instrument at all times and available to local and national authorities upon request.

X-ray tubes do not require radioactive material licenses or leak tests, but do require approvals and licenses which vary from state to state. In addition, fail-safe x-ray warning lights should be illuminated whenever an x-ray tube is energized. Provisions listed above concerning radiation safety regulations, shielding, training, and responsible personnel apply to x-ray tubes just as to radioactive sources. In addition, a log of the times and operating conditions should be kept whenever an x-ray tube is energized. An additional hazard present with x-ray tubes is the danger of electric shock from the high voltage supply, however, if the tube is properly positioned within the instrument, this is only a negligible risk. Any instrument (x-ray tube or radioisotope based) is capable of delivering an electric shock from the basic circuitry when the system is inappropriately opened.

5.3 Radiation monitoring equipment should be used with the handling and operation of the instrument. The operator and the surrounding environment should be monitored continually for analyst exposure to radiation. Thermal luminescent detectors (TLD) in the form of badges and rings are used to monitor operator radiation exposure. The TLDs or badges should be worn in the area of maximum exposure. The maximum permissible whole-body dose from occupational exposure is 5 Roentgen Equivalent Man (REM) per year. Possible exposure pathways for radiation to enter the body are ingestion, inhaling, and absorption. The best precaution to prevent radiation exposure is distance and shielding.

6.0 EQUIPMENT AND SUPPLIES

The mention of trade names or commercial products in this manual is for illustrative purposes only, and does not constitute an EPA endorsement or exclusive recommendation for

use. The products and instrument settings cited in SW-846 methods represent those products and settings used during method development or subsequently evaluated by the Agency. Glassware, reagents, supplies, equipment, and settings other than those listed in this manual may be employed provided that method performance appropriate for the intended application has been demonstrated and documented.

6.1 FPXRF spectrometer -- An FPXRF spectrometer consists of four major components: (1) a source that provides x-rays; (2) a sample presentation device; (3) a detector that converts x-ray-generated photons emitted from the sample into measurable electronic signals; and (4) a data processing unit that contains an emission or fluorescence energy analyzer, such as an MCA, that processes the signals into an x-ray energy spectrum from which elemental concentrations in the sample may be calculated, and a data display and storage system. These components and additional, optional items, are discussed below.

6.1.1 Excitation sources -- FPXRF instruments use either a sealed radioisotope source or an x-ray tube to provide the excitation source. Many FPXRF instruments use sealed radioisotope sources to produce x-rays in order to irradiate samples. The FPXRF instrument may contain between one and three radioisotope sources. Common radioisotope sources used for analysis for metals in soils are iron Fe-55 (^{55}Fe), cadmium Cd-109 (^{109}Cd), americium Am-241 (^{241}Am), and curium Cm-244 (^{244}Cm). These sources may be contained in a probe along with a window and the detector; the probe may be connected to a data reduction and handling system by means of a flexible cable. Alternatively, the sources, window, and detector may be included in the same unit as the data reduction and handling system.

The relative strength of the radioisotope sources is measured in units of millicuries (mCi). All other components of the FPXRF system being equal, the stronger the source, the greater the sensitivity and precision of a given instrument. Radioisotope sources undergo constant decay. In fact, it is this decay process that emits the primary x-rays used to excite samples for FPXRF analysis. The decay of radioisotopes is measured in "half-lives." The half-life of a radioisotope is defined as the length of time required to reduce the radioisotopes strength or activity by half. Developers of FPXRF technologies recommend source replacement at regular intervals based on the source's half-life. This is due to the ever increasing time required for the analysis rather than a decrease in instrument performance. The characteristic x-rays emitted from each of the different sources have energies capable of exciting a certain range of analytes in a sample. Table 2 summarizes the characteristics of four common radioisotope sources.

X-ray tubes have higher radiation output, no intrinsic lifetime limit, produce constant output over their lifetime, and do not have the disposal problems of radioactive sources but are just now appearing in FPXRF instruments. An electrically-excited x-ray tube operates by bombarding an anode with electrons accelerated by a high voltage. The electrons gain an energy in electron volts equal to the accelerating voltage and can excite atomic transitions in the anode, which then produces characteristic x-rays. These characteristic x-rays are emitted through a window which contains the vacuum necessary for the electron acceleration. An important difference between x-ray tubes and radioactive sources is that the electrons which bombard the anode also produce a continuum of x-rays across a broad range of energies in addition to the characteristic x-rays. This continuum is weak compared to the characteristic x-rays but can provide substantial excitation since it covers a broad energy range. It has the undesired property of producing background in the spectrum near the analyte x-ray lines when it is scattered by the sample. For this reason a filter is often used between the x-ray tube and the sample to suppress the continuum radiation while passing the characteristic x-rays from the anode. This filter is sometimes incorporated into the window of the x-ray tube. The choice of

accelerating voltage is governed both by the anode material, since the electrons must have sufficient energy to excite the anode, which requires a voltage greater than the absorption edge of the anode material and by the instrument's ability to cool the x-ray tube. The anode is most efficiently excited by voltages 2 to 2.5 times the edge energy (most x-rays per unit power to the tube), although voltages as low as 1.5 times the absorption edge energy will work. The characteristic x-rays emitted by the anode are capable of exciting a range of elements in the sample just as with a radioactive source. Table 3 gives the recommended operating voltages and the sample elements excited for some common anodes.

6.1.2 Sample presentation device -- FPXRF instruments can be operated in two modes: in situ and intrusive. If operated in the in situ mode, the probe window is placed in direct contact with the soil surface to be analyzed. When an FPXRF instrument is operated in the intrusive mode, a soil or sediment sample must be collected, prepared, and placed in a sample cup. For FPXRF instruments operated in the intrusive mode, the probe may be rotated so that the window faces either upward or downward. A protective sample cover is placed over the window, and the sample cup is placed on top of the window inside the protective sample cover for analysis.

6.1.3 Detectors -- The detectors in the FPXRF instruments can be either solid-state detectors or gas-filled, proportional counter detectors. Common solid-state detectors include mercuric iodide (HgI_2), silicon pin diode and lithium-drifted silicon $\text{Si}(\text{Li})$. The HgI_2 detector is operated at a moderately subambient temperature controlled by a low power thermoelectric cooler. The silicon pin diode detector also is cooled via the thermoelectric Peltier effect. The $\text{Si}(\text{Li})$ detector must be cooled to at least -90°C either with liquid nitrogen or by thermoelectric cooling via the Peltier effect. Instruments with a $\text{Si}(\text{Li})$ detector have an internal liquid nitrogen dewar with a capacity of 0.5 to 1.0 L. Proportional counter detectors are rugged and lightweight, which are important features of a field portable detector. However, the resolution of a proportional counter detector is not as good as that of a solid-state detector. The energy resolution of a detector for characteristic x-rays is usually expressed in terms of full width at half-maximum (FWHM) height of the manganese K_α peak at 5.89 keV. The typical resolutions of the above mentioned detectors are as follows: HgI_2 –270 eV; silicon pin diode–250 eV; $\text{Si}(\text{Li})$ –170 eV; and gas-filled, proportional counter–750 eV.

During operation of a solid-state detector, an x-ray photon strikes a biased, solid-state crystal and loses energy in the crystal by producing electron-hole pairs. The electric charge produced is collected and provides a current pulse that is directly proportional to the energy of the x-ray photon absorbed by the crystal of the detector. A gas-filled, proportional counter detector is an ionization chamber filled with a mixture of noble and other gases. An x-ray photon entering the chamber ionizes the gas atoms. The electric charge produced is collected and provides an electric signal that is directly proportional to the energy of the x-ray photon absorbed by the gas in the detector.

6.1.4 Data processing units -- The key component in the data processing unit of an FPXRF instrument is the MCA. The MCA receives pulses from the detector and sorts them by their amplitudes (energy level). The MCA counts pulses per second to determine the height of the peak in a spectrum, which is indicative of the target analyte's concentration. The spectrum of element peaks are built on the MCA. The MCAs in FPXRF instruments have from 256 to 2,048 channels. The concentrations of target analytes are usually shown in ppm on a liquid crystal display (LCD) in the instrument. FPXRF instruments can store both spectra and from 3,000 to 5,000 sets of numerical analytical results. Most FPXRF instruments are menu-driven from software built into the

units or from PCs. Once the data-storage memory of an FPXRF unit is full or at any other time, data can be downloaded by means of an RS-232 port and cable to a PC.

6.2 Spare battery and battery charger.

6.3 Polyethylene sample cups -- 31 to 40 mm in diameter with collar, or equivalent (appropriate for FPXRF instrument).

6.4 X-ray window film -- Mylar™, Kapton™, Spectrolene™, polypropylene, or equivalent; 2.5 to 6.0 µm thick.

6.5 Mortar and pestle -- Glass, agate, or aluminum oxide; for grinding soil and sediment samples.

6.6 Containers -- Glass or plastic to store samples.

6.7 Sieves -- 60-mesh (0.25 mm), stainless-steel, Nylon, or equivalent for preparing soil and sediment samples.

6.8 Trowels -- For smoothing soil surfaces and collecting soil samples.

6.9 Plastic bags -- Used for collection and homogenization of soil samples.

6.10 Drying oven -- Standard convection or toaster oven, for soil and sediment samples that require drying.

7.0 REAGENTS AND STANDARDS

7.1 Reagent grade chemicals must be used in all tests. Unless otherwise indicated, it is intended that all reagents conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available. Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

7.2 Pure element standards -- Each pure, single-element standard is intended to produce strong characteristic x-ray peaks of the element of interest only. Other elements present must not contribute to the fluorescence spectrum. A set of pure element standards for commonly sought analytes is supplied by the instrument manufacturer, if designated for the instrument; not all instruments require the pure element standards. The standards are used to set the region of interest (ROI) for each element. They also can be used as energy calibration and resolution check samples.

7.3 Site-specific calibration standards -- Instruments that employ fundamental parameters (FP) or similar mathematical models in minimizing matrix effects may not require SSCS. If the FP calibration model is to be optimized or if empirical calibration is necessary, then SSCSs must be collected, prepared, and analyzed.

7.3.1 The SSCS must be representative of the matrix to be analyzed by FPXRF. These samples must be well homogenized. A minimum of 10 samples spanning the concentration ranges of the analytes of interest and of the interfering elements must be obtained from the site. A sample size of 4 to 8 ounces is recommended, and standard glass sampling jars should be used.

7.3.2 Each sample should be oven-dried for 2 to 4 hr at a temperature of less than 150 °C. If mercury is to be analyzed, a separate sample portion should be dried at ambient temperature as heating may volatilize the mercury. When the sample is dry, all large, organic debris and nonrepresentative material, such as twigs, leaves, roots, insects, asphalt, and rock should be removed. The sample should be homogenized (see Sec. 7.3.3) and then a representative portion ground with a mortar and pestle or other mechanical means, prior to passing through a 60-mesh sieve. Only the coarse rock fraction should remain on the screen.

7.3.3 The sample should be homogenized by using a riffle splitter or by placing 150 to 200 g of the dried, sieved sample on a piece of kraft or butcher paper about 1.5 by 1.5 feet in size. Each corner of the paper should be lifted alternately, rolling the soil over on itself and toward the opposite corner. The soil should be rolled on itself 20 times. Approximately 5 g of the sample should then be removed and placed in a sample cup for FPXRF analysis. The rest of the prepared sample should be sent off site for ICP or AA analysis. The method use for confirmatory analysis should meet the data quality objectives of the project.

7.4 Blank samples -- The blank samples should be from a "clean" quartz or silicon dioxide matrix that is free of any analytes at concentrations above the established lower limit of detection. These samples are used to monitor for cross-contamination and laboratory-induced contaminants or interferences.

7.5 Standard reference materials -- Standard reference materials (SRMs) are standards containing certified amounts of metals in soil or sediment. These standards are used for accuracy and performance checks of FPXRF analyses. SRMs can be obtained from the National Institute of Standards and Technology (NIST), the U.S. Geological Survey (USGS), the Canadian National Research Council, and the national bureau of standards in foreign nations. Pertinent NIST SRMs for FPXRF analysis include 2704, Buffalo River Sediment; 2709, San Joaquin Soil; and 2710 and 2711, Montana Soil. These SRMs contain soil or sediment from actual sites that has been analyzed using independent inorganic analytical methods by many different laboratories. When these SRMs are unavailable, alternate standards may be used (e.g., NIST 2702).

8.0 SAMPLE COLLECTION, PRESERVATION, AND STORAGE

Sample handling and preservation procedures used in FPXRF analyses should follow the guidelines in Chapter Three, "Inorganic Analytes."

9.0 QUALITY CONTROL

9.1 Follow the manufacturer's instructions for the quality control procedures specific to use of the testing product. Refer to Chapter One for additional guidance on quality assurance (QA) and quality control (QC) protocols. Any effort involving the collection of analytical data should include development of a structured and systematic planning document, such as a Quality Assurance Project Plan (QAPP) or a Sampling and Analysis Plan (SAP), which translates project objectives and specifications into directions for those that will implement the project and assess the results.

9.2 Energy calibration check -- To determine whether an FPXRF instrument is operating within resolution and stability tolerances, an energy calibration check should be run. The energy calibration check determines whether the characteristic x-ray lines are shifting,

which would indicate drift within the instrument. As discussed in Sec. 4.10, this check also serves as a gain check in the event that ambient temperatures are fluctuating greatly (more than 10 °F).

9.2.1 The energy calibration check should be run at a frequency consistent with manufacturer's recommendations. Generally, this would be at the beginning of each working day, after the batteries are changed or the instrument is shut off, at the end of each working day, and at any other time when the instrument operator believes that drift is occurring during analysis. A pure element such as iron, manganese, copper, or lead is often used for the energy calibration check. A manufacturer-recommended count time per source should be used for the check.

9.2.2 The instrument manufacturer's manual specifies the channel or kiloelectron volt level at which a pure element peak should appear and the expected intensity of the peak. The intensity and channel number of the pure element as measured using the source should be checked and compared to the manufacturer's recommendation. If the energy calibration check does not meet the manufacturer's criteria, then the pure element sample should be repositioned and reanalyzed. If the criteria are still not met, then an energy calibration should be performed as described in the manufacturer's manual. With some FPXRF instruments, once a spectrum is acquired from the energy calibration check, the peak can be optimized and realigned to the manufacturer's specifications using their software.

9.3 Blank samples -- Two types of blank samples should be analyzed for FPXRF analysis, specifically, instrument blanks and method blanks.

9.3.1 An instrument blank is used to verify that no contamination exists in the spectrometer or on the probe window. The instrument blank can be silicon dioxide, a polytetrafluoroethylene (PTFE) block, a quartz block, "clean" sand, or lithium carbonate. This instrument blank should be analyzed on each working day before and after analyses are conducted and once per every twenty samples. An instrument blank should also be analyzed whenever contamination is suspected by the analyst. The frequency of analysis will vary with the data quality objectives of the project. A manufacturer-recommended count time per source should be used for the blank analysis. No element concentrations above the established lower limit of detection should be found in the instrument blank. If concentrations exceed these limits, then the probe window and the check sample should be checked for contamination. If contamination is not a problem, then the instrument must be "zeroed" by following the manufacturer's instructions.

9.3.2 A method blank is used to monitor for laboratory-induced contaminants or interferences. The method blank can be "clean" silica sand or lithium carbonate that undergoes the same preparation procedure as the samples. A method blank must be analyzed at least daily. The frequency of analysis will depend on the data quality objectives of the project. If the method blank does not contain the target analyte at a level that interferes with the project-specific data quality objectives then the method blank would be considered acceptable. In the absence of project-specific data quality objectives, if the blank is less than the lowest level of detection or less than 10% of the lowest sample concentration for the analyte, whichever is greater, then the method blank would be considered acceptable. If the method blank cannot be considered acceptable, the cause of the problem must be identified, and all samples analyzed with the method blank must be reanalyzed.

9.4 Calibration verification checks -- A calibration verification check sample is used to check the accuracy of the instrument and to assess the stability and consistency of the analysis for the analytes of interest. A check sample should be analyzed at the beginning of each working day, during active sample analyses, and at the end of each working day. The frequency of calibration checks during active analysis will depend on the data quality objectives of the project. The check sample should be a well characterized soil sample from the site that is representative of site samples in terms of particle size and degree of homogeneity and that contains contaminants at concentrations near the action levels. If a site-specific sample is not available, then an NIST or other SRM that contains the analytes of interest can be used to verify the accuracy of the instrument. The measured value for each target analyte should be within ± 20 percent (%D) of the true value for the calibration verification check to be acceptable. If a measured value falls outside this range, then the check sample should be reanalyzed. If the value continues to fall outside the acceptance range, the instrument should be recalibrated, and the batch of samples analyzed before the unacceptable calibration verification check must be reanalyzed.

9.5 Precision measurements -- The precision of the method is monitored by analyzing a sample with low, moderate, or high concentrations of target analytes. The frequency of precision measurements will depend on the data quality objectives for the data. A minimum of one precision sample should be run per day. Each precision sample should be analyzed 7 times in replicate. It is recommended that precision measurements be obtained for samples with varying concentration ranges to assess the effect of concentration on method precision. Determining method precision for analytes at concentrations near the site action levels can be extremely important if the FPXRF results are to be used in an enforcement action; therefore, selection of at least one sample with target analyte concentrations at or near the site action levels or levels of concern is recommended. A precision sample is analyzed by the instrument for the same field analysis time as used for other project samples. The relative standard deviation (RSD) of the sample mean is used to assess method precision. For FPXRF data to be considered adequately precise, the RSD should not be greater than 20 percent with the exception of chromium. RSD values for chromium should not be greater than 30 percent. If both in situ and intrusive analytical techniques are used during the course of one day, it is recommended that separate precision calculations be performed for each analysis type.

The equation for calculating RSD is as follows:

$$\text{RSD} = (\text{SD}/\text{Mean Concentration}) \times 100$$

where:

RSD	=	Relative standard deviation for the precision measurement for the analyte
SD	=	Standard deviation of the concentration for the analyte
Mean concentration	=	Mean concentration for the analyte

The precision or reproducibility of a measurement will improve with increasing count time, however, increasing the count time by a factor of 4 will provide only 2 times better precision, so there is a point of diminishing return. Increasing the count time also improves the sensitivity, but decreases sample throughput.

9.6 The lower limits of detection should be established from actual measured performance based on spike recoveries in the matrix of concern or from acceptable method performance on a certified reference material of the appropriate matrix and within the appropriate calibration range for the application. This is considered the best estimate of the true method sensitivity as opposed to a statistical determination based on the standard deviation of

replicate analyses of a low-concentration sample. While the statistical approach demonstrates the potential data variability for a given sample matrix at one point in time, it does not represent what can be detected or most importantly the lowest concentration that can be calibrated. For this reason the sensitivity should be established as the lowest point of detection based on acceptable target analyte recovery in the desired sample matrix.

9.7 Confirmatory samples -- The comparability of the FPXRF analysis is determined by submitting FPXRF-analyzed samples for analysis at a laboratory. The method of confirmatory analysis must meet the project and XRF measurement data quality objectives. The confirmatory samples must be splits of the well homogenized sample material. In some cases the prepared sample cups can be submitted. A minimum of 1 sample for each 20 FPXRF-analyzed samples should be submitted for confirmatory analysis. This frequency will depend on project-specific data quality objectives. The confirmatory analyses can also be used to verify the quality of the FPXRF data. The confirmatory samples should be selected from the lower, middle, and upper range of concentrations measured by the FPXRF. They should also include samples with analyte concentrations at or near the site action levels. The results of the confirmatory analysis and FPXRF analyses should be evaluated with a least squares linear regression analysis. If the measured concentrations span more than one order of magnitude, the data should be log-transformed to standardize variance which is proportional to the magnitude of measurement. The correlation coefficient (r) for the results should be 0.7 or greater for the FPXRF data to be considered screening level data. If the r is 0.9 or greater and inferential statistics indicate the FPXRF data and the confirmatory data are statistically equivalent at a 99 percent confidence level, the data could potentially meet definitive level data criteria.

10.0 CALIBRATION AND STANDARDIZATION

10.1 Instrument calibration -- Instrument calibration procedures vary among FPXRF instruments. Users of this method should follow the calibration procedures outlined in the operator's manual for each specific FPXRF instrument. Generally, however, three types of calibration procedures exist for FPXRF instruments, namely: FP calibration, empirical calibration, and the Compton peak ratio or normalization method. These three types of calibration are discussed below.

10.2 Fundamental parameters calibration -- FP calibration procedures are extremely variable. An FP calibration provides the analyst with a "standardless" calibration. The advantages of FP calibrations over empirical calibrations include the following:

- No previously collected site-specific samples are necessary, although site-specific samples with confirmed and validated analytical results for all elements present could be used.
- Cost is reduced because fewer confirmatory laboratory results or calibration standards are necessary.

However, the analyst should be aware of the limitations imposed on FP calibration by particle size and matrix effects. These limitations can be minimized by adhering to the preparation procedure described in Sec. 7.3. The two FP calibration processes discussed below are based on an effective energy FP routine and a back scatter with FP (BFP) routine. Each FPXRF FP calibration process is based on a different iterative algorithmic method. The calibration procedure for each routine is explained in detail in the manufacturer's user manual for each FPXRF instrument; in addition, training courses are offered for each instrument.

10.2.1 Effective energy FP calibration -- The effective energy FP calibration is performed by the manufacturer before an instrument is sent to the analyst. Although SSCS can be used, the calibration relies on pure element standards or SRMs such as those obtained from NIST for the FP calibration. The effective energy routine relies on the spectrometer response to pure elements and FP iterative algorithms to compensate for various matrix effects.

Alpha coefficients are calculated using a variation of the Sherman equation, which calculates theoretical intensities from the measurement of pure element samples. These coefficients indicate the quantitative effect of each matrix element on an analyte's measured x-ray intensity. Next, the Lachance Traill algorithm is solved as a set of simultaneous equations based on the theoretical intensities. The alpha coefficients are then downloaded into the specific instrument.

The working effective energy FP calibration curve must be verified before sample analysis begins on each working day, after every 20 samples are analyzed, and at the end of sampling. This verification is performed by analyzing either an NIST SRM or an SSCS that is representative of the site-specific samples. This SRM or SSCS serves as a calibration check. A manufacturer-recommended count time per source should be used for the calibration check. The analyst must then adjust the y-intercept and slope of the calibration curve to best fit the known concentrations of target analytes in the SRM or SSCS.

A percent difference (%D) is then calculated for each target analyte. The %D should be within ± 20 percent of the certified value for each analyte. If the %D falls outside this acceptance range, then the calibration curve should be adjusted by varying the slope of the line or the y-intercept value for the analyte. The SRM or SSCS is reanalyzed until the %D falls within ± 20 percent. The group of 20 samples analyzed before an out-of-control calibration check should be reanalyzed.

The equation to calibrate %D is as follows:

$$\%D = ((C_s - C_k) / C_k) \times 100$$

where:

%D = Percent difference

C_k = Certified concentration of standard sample

C_s = Measured concentration of standard sample

10.2.2 BFP calibration -- BFP calibration relies on the ability of the liquid nitrogen-cooled, Si(Li) solid-state detector to separate the coherent (Compton) and incoherent (Rayleigh) backscatter peaks of primary radiation. These peak intensities are known to be a function of sample composition, and the ratio of the Compton to Rayleigh peak is a function of the mass absorption of the sample. The calibration procedure is explained in detail in the instrument manufacturer's manual. Following is a general description of the BFP calibration procedure.

The concentrations of all detected and quantified elements are entered into the computer software system. Certified element results for an NIST SRM or confirmed and validated results for an SSCS can be used. In addition, the concentrations of oxygen and silicon must be entered; these two concentrations are not found in standard metals analyses. The manufacturer provides silicon and oxygen concentrations for typical soil types. Pure element standards are then analyzed using a manufacturer-recommended

count time per source. The results are used to calculate correction factors in order to adjust for spectrum overlap of elements.

The working BFP calibration curve must be verified before sample analysis begins on each working day, after every 20 samples are analyzed, and at the end of the analysis. This verification is performed by analyzing either an NIST SRM or an SSCS that is representative of the site-specific samples. This SRM or SSCS serves as a calibration check. The standard sample is analyzed using a manufacturer-recommended count time per source to check the calibration curve. The analyst must then adjust the y-intercept and slope of the calibration curve to best fit the known concentrations of target analytes in the SRM or SSCS.

A %D is then calculated for each target analyte. The %D should fall within ± 20 percent of the certified value for each analyte. If the %D falls outside this acceptance range, then the calibration curve should be adjusted by varying the slope of the line the y-intercept value for the analyte. The standard sample is reanalyzed until the %D falls within ± 20 percent. The group of 20 samples analyzed before an out-of-control calibration check should be reanalyzed.

10.3 Empirical calibration -- An empirical calibration can be performed with SSCS, site-typical standards, or standards prepared from metal oxides. A discussion of SSCS is included in Sec. 7.3; if no previously characterized samples exist for a specific site, site-typical standards can be used. Site-typical standards may be selected from commercially available characterized soils or from SSCS prepared for another site. The site-typical standards should closely approximate the site's soil matrix with respect to particle size distribution, mineralogy, and contaminant analytes. If neither SSCS nor site-typical standards are available, it is possible to make gravimetric standards by adding metal oxides to a "clean" sand or silicon dioxide matrix that simulates soil. Metal oxides can be purchased from various chemical vendors. If standards are made on site, a balance capable of weighing items to at least two decimal places is necessary. Concentrated ICP or AA standard solutions can also be used to make standards. These solutions are available in concentrations of 10,000 parts per million, thus only small volumes have to be added to the soil.

An empirical calibration using SSCS involves analysis of SSCS by the FPXRF instrument and by a conventional analytical method such as ICP or AA. A total acid digestion procedure should be used by the laboratory for sample preparation. Generally, a minimum of 10 and a maximum of 30 well characterized SSCS, site-typical standards, or prepared metal oxide standards are necessary to perform an adequate empirical calibration. The exact number of standards depends on the number of analytes of interest and interfering elements. Theoretically, an empirical calibration with SSCS should provide the most accurate data for a site because the calibration compensates for site-specific matrix effects.

The first step in an empirical calibration is to analyze the pure element standards for the elements of interest. This enables the instrument to set channel limits for each element for spectral deconvolution. Next the SSCS, site-typical standards, or prepared metal oxide standards are analyzed using a count time of 200 seconds per source or a count time recommended by the manufacturer. This will produce a spectrum and net intensity of each analyte in each standard. The analyte concentrations for each standard are then entered into the instrument software; these concentrations are those obtained from the laboratory, the certified results, or the gravimetrically determined concentrations of the prepared standards. This gives the instrument analyte values to regress against corresponding intensities during the modeling stage. The regression equation correlates the concentrations of an analyte with its net intensity.

The calibration equation is developed using a least squares fit regression analysis. After the regression terms to be used in the equation are defined, a mathematical equation can be developed to calculate the analyte concentration in an unknown sample. In some FPXRF instruments, the software of the instrument calculates the regression equation. The software uses calculated intercept and slope values to form a multiterm equation. In conjunction with the software in the instrument, the operator can adjust the multiterm equation to minimize interelement interferences and optimize the intensity calibration curve.

It is possible to define up to six linear or nonlinear terms in the regression equation. Terms can be added and deleted to optimize the equation. The goal is to produce an equation with the smallest regression error and the highest correlation coefficient. These values are automatically computed by the software as the regression terms are added, deleted, or modified. It is also possible to delete data points from the regression line if these points are significant outliers or if they are heavily weighing the data. Once the regression equation has been selected for an analyte, the equation can be entered into the software for quantitation of analytes in subsequent samples. For an empirical calibration to be acceptable, the regression equation for a specific analyte should have a correlation coefficient of 0.98 or greater or meet the DQOs of the project.

In an empirical calibration, one must apply the DQOs of the project and ascertain critical or action levels for the analytes of interest. It is within these concentration ranges or around these action levels that the FPXRF instrument should be calibrated most accurately. It may not be possible to develop a good regression equation over several orders of analyte concentration.

10.4 Compton normalization method -- The Compton normalization method is based on analysis of a single, certified standard and normalization for the Compton peak. The Compton peak is produced from incoherent backscattering of x-ray radiation from the excitation source and is present in the spectrum of every sample. The Compton peak intensity changes with differing matrices. Generally, matrices dominated by lighter elements produce a larger Compton peak, and those dominated by heavier elements produce a smaller Compton peak. Normalizing to the Compton peak can reduce problems with varying matrix effects among samples. Compton normalization is similar to the use of internal standards in organics analysis. The Compton normalization method may not be effective when analyte concentrations exceed a few percent.

The certified standard used for this type of calibration could be an NIST SRM such as 2710 or 2711. The SRM must be a matrix similar to the samples and must contain the analytes of interests at concentrations near those expected in the samples. First, a response factor has to be determined for each analyte. This factor is calculated by dividing the net peak intensity by the analyte concentration. The net peak intensity is gross intensity corrected for baseline reading. Concentrations of analytes in samples are then determined by multiplying the baseline corrected analyte signal intensity by the normalization factor and by the response factor. The normalization factor is the quotient of the baseline corrected Compton K_{α} peak intensity of the SRM divided by that of the samples. Depending on the FPXRF instrument used, these calculations may be done manually or by the instrument software.

11.0 PROCEDURE

11.1 Operation of the various FPXRF instruments will vary according to the manufacturers' protocols. Before operating any FPXRF instrument, one should consult the manufacturer's manual. Most manufacturers recommend that their instruments be allowed to warm up for 15 to 30 minutes before analysis of samples. This will help alleviate drift or energy calibration problems later during analysis.

11.2 Each FPXRF instrument should be operated according to the manufacturer's recommendations. There are two modes in which FPXRF instruments can be operated: in situ and intrusive. The in situ mode involves analysis of an undisturbed soil sediment or sample. Intrusive analysis involves collection and preparation of a soil or sediment sample before analysis. Some FPXRF instruments can operate in both modes of analysis, while others are designed to operate in only one mode. The two modes of analysis are discussed below.

11.3 For in situ analysis, remove any large or nonrepresentative debris from the soil surface before analysis. This debris includes rocks, pebbles, leaves, vegetation, roots, and concrete. Also, the soil surface must be as smooth as possible so that the probe window will have good contact with the surface. This may require some leveling of the surface with a stainless-steel trowel. During the study conducted to provide example performance data for this method, this modest amount of sample preparation was found to take less than 5 min per sample location. The last requirement is that the soil or sediment not be saturated with water. Manufacturers state that their FPXRF instruments will perform adequately for soils with moisture contents of 5 to 20 percent but will not perform well for saturated soils, especially if ponded water exists on the surface. Another recommended technique for in situ analysis is to tamp the soil to increase soil density and compactness for better repeatability and representativeness. This condition is especially important for heavy element analysis, such as barium. Source count times for in situ analysis usually range from 30 to 120 seconds, but source count times will vary among instruments and depending on the desired method sensitivity. Due to the heterogeneous nature of the soil sample, in situ analysis can provide only "screening" type data.

11.4 For intrusive analysis of surface or sediment, it is recommended that a sample be collected from a 4- by 4-inch square that is 1 inch deep. This will produce a soil sample of approximately 375 g or 250 cm³, which is enough soil to fill an 8-ounce jar. However, the exact dimensions and sample depth should take into consideration the heterogeneous deposition of contaminants and will ultimately depend on the desired project-specific data quality objectives. The sample should be homogenized, dried, and ground before analysis. The sample can be homogenized before or after drying. The homogenization technique to be used after drying is discussed in Sec. 4.2. If the sample is homogenized before drying, it should be thoroughly mixed in a beaker or similar container, or if the sample is moist and has a high clay content, it can be kneaded in a plastic bag. One way to monitor homogenization when the sample is kneaded in a plastic bag is to add sodium fluorescein dye to the sample. After the moist sample has been homogenized, it is examined under an ultraviolet light to assess the distribution of sodium fluorescein throughout the sample. If the fluorescent dye is evenly distributed in the sample, homogenization is considered complete; if the dye is not evenly distributed, mixing should continue until the sample has been thoroughly homogenized. During the study conducted to provide data for this method, the time necessary for homogenization procedure using the fluorescein dye ranged from 3 to 5 min per sample. As demonstrated in Secs. 13.5 and 13.7, homogenization has the greatest impact on the reduction of sampling variability. It produces little or no contamination. Often, the direct analysis through the plastic bag is possible without the more labor intensive steps of drying, grinding, and sieving given in Secs. 11.5 and 11.6. Of course, to achieve the best data quality possible all four steps should be followed.

11.5 Once the soil or sediment sample has been homogenized, it should be dried. This can be accomplished with a toaster oven or convection oven. A small aliquot of the sample (20 to 50 g) is placed in a suitable container for drying. The sample should be dried for 2 to 4 hr in the convection or toaster oven at a temperature not greater than 150 °C. Samples may also be air dried under ambient temperature conditions using a 10- to 20-g portion. Regardless of what drying mechanism is used, the drying process is considered complete when a constant sample weight can be obtained. Care should be taken to avoid sample cross-contamination and these measures can be evaluated by including an appropriate method blank sample along with any sample preparation process.

CAUTION: Microwave drying is not a recommended procedure. Field studies have shown that microwave drying can increase variability between the FPXRF data and confirmatory analysis. High levels of metals in a sample can cause arcing in the microwave oven, and sometimes slag forms in the sample. Microwave oven drying can also melt plastic containers used to hold the sample.

11.6 The homogenized dried sample material should be ground with a mortar and pestle and passed through a 60-mesh sieve to achieve a uniform particle size. Sample grinding should continue until at least 90 percent of the original sample passes through the sieve. The grinding step normally takes an average of 10 min per sample. An aliquot of the sieved sample should then be placed in a 31.0-mm polyethylene sample cup (or equivalent) for analysis. The sample cup should be one-half to three-quarters full at a minimum. The sample cup should be covered with a 2.5 μm Mylar (or equivalent) film for analysis. The rest of the soil sample should be placed in a jar, labeled, and archived for possible confirmation analysis. All equipment including the mortar, pestle, and sieves must be thoroughly cleaned so that any cross-contamination is below the established lower limit of detection of the procedure or DQOs of the analysis. If all recommended sample preparation steps are followed, there is a high probability the desired laboratory data quality may be obtained.

12.0 DATA ANALYSIS AND CALCULATIONS

Most FPXRF instruments have software capable of storing all analytical results and spectra. The results are displayed in ppm and can be downloaded to a personal computer, which can be used to provide a hard copy printout. Individual measurements that are smaller than three times their associated SD should not be used for quantitation. See the manufacturer's instructions regarding data analysis and calculations.

13.0 METHOD PERFORMANCE

13.1 Performance data and related information are provided in SW-846 methods only as examples and guidance. The data do not represent required performance criteria for users of the methods. Instead, performance criteria should be developed on a project-specific basis, and the laboratory should establish in-house QC performance criteria for the application of this method. These performance data are not intended to be and must not be used as absolute QC acceptance criteria for purposes of laboratory accreditation.

13.2 The sections to follow discuss three performance evaluation factors; namely, precision, accuracy, and comparability. The example data presented in Tables 4 through 8 were generated from results obtained from six FPXRF instruments (see Sec. 13.3). The soil samples analyzed by the six FPXRF instruments were collected from two sites in the United States. The soil samples contained several of the target analytes at concentrations ranging from "nondetect" to tens of thousands of mg/kg. These data are provided for guidance purposes only.

13.3 The six FPXRF instruments included the TN 9000 and TN Lead Analyzer manufactured by TN Spectrace; the X-MET 920 with a SiLi detector and X-MET 920 with a gas-filled proportional detector manufactured by Metorex, Inc.; the XL Spectrum Analyzer manufactured by Niton; and the MAP Spectrum Analyzer manufactured by Scitec. The TN 9000 and TN Lead Analyzer both have a HgI_2 detector. The TN 9000 utilized an Fe-55, Cd-109, and Am-241 source. The TN Lead Analyzer had only a Cd-109 source. The X-Met 920 with the SiLi detector had a Cd-109 and Am-241 source. The X-MET 920 with the gas-filled proportional detector had only a Cd-109 source. The XL Spectrum Analyzer utilized a silicon pin-diode

detector and a Cd-109 source. The MAP Spectrum Analyzer utilized a solid-state silicon detector and a Cd-109 source.

13.4 All example data presented in Tables 4 through 8 were generated using the following calibrations and source count times. The TN 9000 and TN Lead Analyzer were calibrated using fundamental parameters using NIST SRM 2710 as a calibration check sample. The TN 9000 was operated using 100, 60, and 60 second count times for the Cd-109, Fe-55, and Am-241 sources, respectively. The TN Lead analyzer was operated using a 60 second count time for the Cd-109 source. The X-MET 920 with the Si(Li) detector was calibrated using fundamental parameters and one well characterized site-specific soil standard as a calibration check. It used 140 and 100 second count times for the Cd-109 and Am-241 sources, respectively. The X-MET 920 with the gas-filled proportional detector was calibrated empirically using between 10 and 20 well characterized site-specific soil standards. It used 120 second times for the Cd-109 source. The XL Spectrum Analyzer utilized NIST SRM 2710 for calibration and the Compton peak normalization procedure for quantitation based on 60 second count times for the Cd-109 source. The MAP Spectrum Analyzer was internally calibrated by the manufacturer. The calibration was checked using a well-characterized site-specific soil standard. It used 240 second times for the Cd-109 source.

13.5 Precision measurements -- The example precision data are presented in Table 4. These data are provided for guidance purposes only. Each of the six FPXRF instruments performed 10 replicate measurements on 12 soil samples that had analyte concentrations ranging from "nondetects" to thousands of mg/kg. Each of the 12 soil samples underwent 4 different preparation techniques from in situ (no preparation) to dried and ground in a sample cup. Therefore, there were 48 precision data points for five of the instruments and 24 precision points for the MAP Spectrum Analyzer. The replicate measurements were taken using the source count times discussed at the beginning of this section.

For each detectable analyte in each precision sample a mean concentration, standard deviation, and RSD was calculated for each analyte. The data presented in Table 4 is an average RSD for the precision samples that had analyte concentrations at 5 to 10 times the lower limit of detection for that analyte for each instrument. Some analytes such as mercury, selenium, silver, and thorium were not detected in any of the precision samples so these analytes are not listed in Table 4. Some analytes such as cadmium, nickel, and tin were only detected at concentrations near the lower limit of detection so that an RSD value calculated at 5 to 10 times this limit was not possible.

One FPXRF instrument collected replicate measurements on an additional nine soil samples to provide a better assessment of the effect of sample preparation on precision. Table 5 shows these results. These data are provided for guidance purposes only. The additional nine soil samples were comprised of three from each texture and had analyte concentrations ranging from near the lower limit of detection for the FPXRF analyzer to thousands of mg/kg. The FPXRF analyzer only collected replicate measurements from three of the preparation methods; no measurements were collected from the in situ homogenized samples. The FPXRF analyzer conducted five replicate measurements of the in situ field samples by taking measurements at five different points within the 4-inch by 4-inch sample square. Ten replicate measurements were collected for both the intrusive undried and unground and intrusive dried and ground samples contained in cups. The cups were shaken between each replicate measurement.

Table 5 shows that the precision dramatically improved from the in situ to the intrusive measurements. In general there was a slight improvement in precision when the sample was dried and ground. Two factors caused the precision for the in situ measurements to be poorer. The major factor is soil heterogeneity. By moving the probe within the 4-inch by 4-inch square,

measurements of different soil samples were actually taking place within the square. Table 5 illustrates the dominant effect of soil heterogeneity. It overwhelmed instrument precision when the FPXRF analyzer was used in this mode. The second factor that caused the RSD values to be higher for the in situ measurements is the fact that only five instead of ten replicates were taken. A lesser number of measurements caused the standard deviation to be larger which in turn elevated the RSD values.

13.6 Accuracy measurements -- Five of the FPXRF instruments (not including the MAP Spectrum Analyzer) analyzed 18 SRMs using the source count times and calibration methods given at the beginning of this section. The 18 SRMs included 9 soil SRMs, 4 stream or river sediment SRMs, 2 sludge SRMs, and 3 ash SRMs. Each of the SRMs contained known concentrations of certain target analytes. A percent recovery was calculated for each analyte in each SRM for each FPXRF instrument. Table 6 presents a summary of this data. With the exception of cadmium, chromium, and nickel, the values presented in Table 6 were generated from the 13 soil and sediment SRMs only. The 2 sludge and 3 ash SRMs were included for cadmium, chromium, and nickel because of the low or nondetectable concentrations of these three analytes in the soil and sediment SRMs.

Only 12 analytes are presented in Table 6. These are the analytes that are of environmental concern and provided a significant number of detections in the SRMs for an accuracy assessment. No data is presented for the X-MET 920 with the gas-filled proportional detector. This FPXRF instrument was calibrated empirically using site-specific soil samples. The percent recovery values from this instrument were very sporadic and the data did not lend itself to presentation in Table 6.

Table 7 provides a more detailed summary of accuracy data for one particular FPXRF instrument (TN 9000) for the 9 soil SRMs and 4 sediment SRMs. These data are provided for guidance purposes only. Table 7 shows the certified value, measured value, and percent recovery for five analytes. These analytes were chosen because they are of environmental concern and were most prevalently certified for in the SRM and detected by the FPXRF instrument. The first nine SRMs are soil and the last 4 SRMs are sediment. Percent recoveries for the four NIST SRMs were often between 90 and 110 percent for all analytes.

13.7 Comparability -- Comparability refers to the confidence with which one data set can be compared to another. In this case, FPXRF data generated from a large study of six FPXRF instruments was compared to SW-846 Methods 3050 and 6010 which are the standard soil extraction for metals and analysis by inductively coupled plasma. An evaluation of comparability was conducted by using linear regression analysis. Three factors were determined using the linear regression. These factors were the y-intercept, the slope of the line, and the coefficient of determination (r^2).

As part of the comparability assessment, the effects of soil type and preparation methods were studied. Three soil types (textures) and four preparation methods were examined during the study. The preparation methods evaluated the cumulative effect of particle size, moisture, and homogenization on comparability. Due to the large volume of data produced during this study, linear regression data for six analytes from only one FPXRF instrument is presented in Table 8. Similar trends in the data were seen for all instruments. These data are provided for guidance purposes only.

Table 8 shows the regression parameters for the whole data set, broken out by soil type, and by preparation method. These data are provided for guidance purposes only. The soil types are as follows: soil 1--sand; soil 2--loam; and soil 3--silty clay. The preparation methods are as follows: preparation 1--in situ in the field; preparation 2--intrusive, sample collected and homogenized; preparation 3--intrusive, with sample in a sample cup but sample still wet and not

ground; and preparation 4—intrusive, with sample dried, ground, passed through a 40-mesh sieve, and placed in sample cup.

For arsenic, copper, lead, and zinc, the comparability to the confirmatory laboratory was excellent with r^2 values ranging from 0.80 to 0.99 for all six FPXRF instruments. The slopes of the regression lines for arsenic, copper, lead, and zinc, were generally between 0.90 and 1.00 indicating the data would need to be corrected very little or not at all to match the confirmatory laboratory data. The r^2 values and slopes of the regression lines for barium and chromium were not as good as for the other for analytes, indicating the data would have to be corrected to match the confirmatory laboratory.

Table 8 demonstrates that there was little effect of soil type on the regression parameters for any of the six analytes. The only exceptions were for barium in soil 1 and copper in soil 3. In both of these cases, however, it is actually a concentration effect and not a soil effect causing the poorer comparability. All barium and copper concentrations in soil 1 and 3, respectively, were less than 350 mg/kg.

Table 8 shows there was a preparation effect on the regression parameters for all six analytes. With the exception of chromium, the regression parameters were primarily improved going from preparation 1 to preparation 2. In this step, the sample was removed from the soil surface, all large debris was removed, and the sample was thoroughly homogenized. The additional two preparation methods did little to improve the regression parameters. This data indicates that homogenization is the most critical factor when comparing the results. It is essential that the sample sent to the confirmatory laboratory match the FPXRF sample as closely as possible.

Sec. 11.0 of this method discusses the time necessary for each of the sample preparation techniques. Based on the data quality objectives for the project, an analyst must decide if it is worth the extra time necessary to dry and grind the sample for small improvements in comparability. Homogenization requires 3 to 5 min. Drying the sample requires one to two hours. Grinding and sieving requires another 10 to 15 min per sample. Lastly, when grinding and sieving is conducted, time has to be allotted to decontaminate the mortars, pestles, and sieves. Drying and grinding the samples and decontamination procedures will often dictate that an extra person be on site so that the analyst can keep up with the sample collection crew. The cost of requiring an extra person on site to prepare samples must be balanced with the gain in data quality and sample throughput.

13.8 The following documents may provide additional guidance and insight on this method and technique:

13.8.1 A. D. Hewitt, "Screening for Metals by X-ray Fluorescence Spectrometry/Response Factor/Compton K_α Peak Normalization Analysis," American Environmental Laboratory, pp 24-32, 1994.

13.8.2 S. Piorek and J. R. Pasmore, "Standardless, In Situ Analysis of Metallic Contaminants in the Natural Environment With a PC-Based, High Resolution Portable X-Ray Analyzer," Third International Symposium on Field Screening Methods for Hazardous Waste and Toxic Chemicals, Las Vegas, Nevada, February 24-26, 1993, Vol 2, pp 1135-1151, 1993.

13.8.3 S. Shefsky, "Sample Handling Strategies for Accurate Lead-in-soil Measurements in the Field and Laboratory," *International Symposium of Field Screening Methods for Hazardous Waste and Toxic Chemicals*, Las Vegas, NV, January 29-31, 1997.

14.0 POLLUTION PREVENTION

14.1 Pollution prevention encompasses any technique that reduces or eliminates the quantity and/or toxicity of waste at the point of generation. Numerous opportunities for pollution prevention exist in laboratory operation. The EPA has established a preferred hierarchy of environmental management techniques that places pollution prevention as the management option of first choice. Whenever feasible, laboratory personnel should use pollution prevention techniques to address their waste generation. When wastes cannot be feasibly reduced at the source, the Agency recommends recycling as the next best option.

14.2 For information about pollution prevention that may be applicable to laboratories and research institutions consult *Less is Better: Laboratory Chemical Management for Waste Reduction* available from the American Chemical Society's Department of Government Relations and Science Policy, 1155 16th St., N.W. Washington, D.C. 20036, <http://www.acs.org>.

15.0 WASTE MANAGEMENT

The Environmental Protection Agency requires that laboratory waste management practices be conducted consistent with all applicable rules and regulations. The Agency urges laboratories to protect the air, water, and land by minimizing and controlling all releases from hoods and bench operations, complying with the letter and spirit of any sewer discharge permits and regulations, and by complying with all solid and hazardous waste regulations, particularly the hazardous waste identification rules and land disposal restrictions. For further information on waste management, consult *The Waste Management Manual for Laboratory Personnel* available from the American Chemical Society at the address listed in Sec. 14.2.

16.0 REFERENCES

1. Metorex, X-MET 920 User's Manual.
2. Spectrace Instruments, "Energy Dispersive X-ray Fluorescence Spectrometry: An Introduction," 1994.
3. TN Spectrace, Spectrace 9000 Field Portable/Benchtop XRF Training and Applications Manual.
4. Unpublished SITE data, received from PRC Environment Management, Inc.

17.0 TABLES, DIAGRAMS, FLOWCHARTS, AND VALIDATION DATA

The following pages contain the tables referenced by this method. A flow diagram of the procedure follows the tables.

TABLE 1

EXAMPLE INTERFERENCE FREE LOWER LIMITS OF DETECTION

Analyte	Chemical Abstract Series Number	Lower Limit of Detection in Quartz Sand (milligrams per kilogram)
Antimony (Sb)	7440-36-0	40
Arsenic (As)	7440-38-0	40
Barium (Ba)	7440-39-3	20
Cadmium (Cd)	7440-43-9	100
Calcium (Ca)	7440-70-2	70
Chromium (Cr)	7440-47-3	150
Cobalt (Co)	7440-48-4	60
Copper (Cu)	7440-50-8	50
Iron (Fe)	7439-89-6	60
Lead (Pb)	7439-92-1	20
Manganese (Mn)	7439-96-5	70
Mercury (Hg)	7439-97-6	30
Molybdenum (Mo)	7439-93-7	10
Nickel (Ni)	7440-02-0	50
Potassium (K)	7440-09-7	200
Rubidium (Rb)	7440-17-7	10
Selenium (Se)	7782-49-2	40
Silver (Ag)	7440-22-4	70
Strontium (Sr)	7440-24-6	10
Thallium (Tl)	7440-28-0	20
Thorium (Th)	7440-29-1	10
Tin (Sn)	7440-31-5	60
Titanium (Ti)	7440-32-6	50
Vanadium (V)	7440-62-2	50
Zinc (Zn)	7440-66-6	50
Zirconium (Zr)	7440-67-7	10

Source: Refs. 1, 2, and 3

These data are provided for guidance purposes only.

TABLE 2
SUMMARY OF RADIOISOTOPE SOURCE CHARACTERISTICS

Source	Activity (mCi)	Half-Life (Years)	Excitation Energy (keV)	Elemental Analysis Range	
Fe-55	20-50	2.7	5.9	Sulfur to Chromium Molybdenum to Barium	K Lines L Lines
Cd-109	5-30	1.3	22.1 and 87.9	Calcium to Rhodium Tantalum to Lead Barium to Uranium	K Lines K Lines L Lines
Am-241	5-30	432	26.4 and 59.6	Copper to Thulium Tungsten to Uranium	K Lines L Lines
Cm-244	60-100	17.8	14.2	Titanium to Selenium Lanthanum to Lead	K Lines L Lines

Source: Refs. 1, 2, and 3

TABLE 3
SUMMARY OF X-RAY TUBE SOURCE CHARACTERISTICS

Anode Material	Recommended Voltage Range (kV)	K-alpha Emission (keV)	Elemental Analysis Range	
Cu	18-22	8.04	Potassium to Cobalt Silver to Gadolinium	K Lines L Lines
Mo	40-50	17.4	Cobalt to Yttrium Europium to Radon	K Lines L Lines
Ag	50-65	22.1	Zinc to Technicium Ytterbium to Neptunium	K Lines L Lines

Source: Ref. 4

Notes: The sample elements excited are chosen by taking as the lower limit the same ratio of excitation line energy to element absorption edge as in Table 2 (approximately 0.45) and the requirement that the excitation line energy be above the element absorption edge as the upper limit (L2 edges used for L lines). K-beta excitation lines were ignored.

TABLE 4
EXAMPLE PRECISION VALUES

Analyte	Average Relative Standard Deviation for Each Instrument at 5 to 10 Times the Lower Limit of Detection					
	TN 9000	TN Lead Analyzer	X-MET 920 (SiLi Detector)	X-MET 920 (Gas-Filled Detector)	XL Spectrum Analyzer	MAP Spectrum Analyzer
Antimony	6.54	NR	NR	NR	NR	NR
Arsenic	5.33	4.11	3.23	1.91	12.47	6.68
Barium	4.02	NR	3.31	5.91	NR	NR
Cadmium	29.84 ^a	NR	24.80 ^a	NR	NR	NR
Calcium	2.16	NR	NR	NR	NR	NR
Chromium	22.25	25.78	22.72	3.91	30.25	NR
Cobalt	33.90	NR	NR	NR	NR	NR
Copper	7.03	9.11	8.49	9.12	12.77	14.86
Iron	1.78	1.67	1.55	NR	2.30	NR
Lead	6.45	5.93	5.05	7.56	6.97	12.16
Manganese	27.04	24.75	NR	NR	NR	NR
Molybdenum	6.95	NR	NR	NR	12.60	NR
Nickel	30.85 ^a	NR	24.92 ^a	20.92 ^a	NA	NR
Potassium	3.90	NR	NR	NR	NR	NR
Rubidium	13.06	NR	NR	NR	32.69 ^a	NR
Strontium	4.28	NR	NR	NR	8.86	NR
Tin	24.32 ^a	NR	NR	NR	NR	NR
Titanium	4.87	NR	NR	NR	NR	NR
Zinc	7.27	7.48	4.26	2.28	10.95	0.83
Zirconium	3.58	NR	NR	NR	6.49	NR

These data are provided for guidance purposes only.

Source: Ref. 4

^a These values are biased high because the concentration of these analytes in the soil samples was near the lower limit of detection for that particular FPXRF instrument.

NR Not reported.

NA Not applicable; analyte was reported but was below the established lower limit detection.

TABLE 5

EXAMPLES OF PRECISION AS AFFECTED BY SAMPLE PREPARATION

Analyte	Average Relative Standard Deviation for Each Preparation Method		
	In Situ-Field	Intrusive- Undried and Unground	Intrusive- Dried and Ground
Antimony	30.1	15.0	14.4
Arsenic	22.5	5.36	3.76
Barium	17.3	3.38	2.90
Cadmium ^a	41.2	30.8	28.3
Calcium	17.5	1.68	1.24
Chromium	17.6	28.5	21.9
Cobalt	28.4	31.1	28.4
Copper	26.4	10.2	7.90
Iron	10.3	1.67	1.57
Lead	25.1	8.55	6.03
Manganese	40.5	12.3	13.0
Mercury	ND	ND	ND
Molybdenum	21.6	20.1	19.2
Nickel ^a	29.8	20.4	18.2
Potassium	18.6	3.04	2.57
Rubidium	29.8	16.2	18.9
Selenium	ND	20.2	19.5
Silver ^a	31.9	31.0	29.2
Strontium	15.2	3.38	3.98
Thallium	39.0	16.0	19.5
Thorium	NR	NR	NR
Tin	ND	14.1	15.3
Titanium	13.3	4.15	3.74
Vanadium	NR	NR	NR
Zinc	26.6	13.3	11.1
Zirconium	20.2	5.63	5.18

These data are provided for guidance purposes only.

Source: Ref. 4

^a These values may be biased high because the concentration of these analytes in the soil samples was near the lower limit of detection.

ND Not detected.

NR Not reported.

TABLE 6
EXAMPLE ACCURACY VALUES

Analyte	Instrument															
	TN 9000				TN Lead Analyzer				X-MET 920 (SiLi Detector)				XL Spectrum Analyzer			
	n	Range of % Rec.	Mean % Rec.	SD	n	Range of % Rec.	Mean % Rec.	SD	n	Range of % Rec.	Mean % Rec.	SD	n	Range of % Rec.	Mean % Rec.	SD
Sb	2	100-149	124.3	NA	--	--	--	--	--	--	--	--	--	--	--	--
As	5	68-115	92.8	17.3	5	44-105	83.4	23.2	4	9.7-91	47.7	39.7	5	38-535	189.8	206
Ba	9	98-198	135.3	36.9	--	--	--	--	9	18-848	168.2	262	--	--	--	--
Cd	2	99-129	114.3	NA	--	--	--	--	6	81-202	110.5	45.7	--	--	--	--
Cr	2	99-178	138.4	NA	--	--	--	--	7	22-273	143.1	93.8	3	98-625	279.2	300
Cu	8	61-140	95.0	28.8	6	38-107	79.1	27.0	11	10-210	111.8	72.1	8	95-480	203.0	147
Fe	6	78-155	103.7	26.1	6	89-159	102.3	28.6	6	48-94	80.4	16.2	6	26-187	108.6	52.9
Pb	11	66-138	98.9	19.2	11	68-131	97.4	18.4	12	23-94	72.7	20.9	13	80-234	107.3	39.9
Mn	4	81-104	93.1	9.70	3	92-152	113.1	33.8	--	--	--	--	--	--	--	--
Ni	3	99-122	109.8	12.0	--	--	--	--	--	--	--	--	3	57-123	87.5	33.5
Sr	8	110-178	132.6	23.8	--	--	--	--	--	--	--	--	7	86-209	125.1	39.5
Zn	11	41-130	94.3	24.0	10	81-133	100.0	19.7	12	46-181	106.6	34.7	11	31-199	94.6	42.5

Source: Ref. 4. These data are provided for guidance purposes only.

n: Number of samples that contained a certified value for the analyte and produced a detectable concentration from the FPXRF instrument.

SD: Standard deviation; NA: Not applicable; only two data points, therefore, a SD was not calculated.

%Rec.: Percent recovery.

-- No data.

TABLE 7
EXAMPLE ACCURACY FOR TN 9000^a

Standard Reference Material	Arsenic			Barium			Copper			Lead			Zinc		
	Cert. Conc.	Meas. Conc.	%Rec.	Cert. Conc.	Meas. Conc.	%Rec.	Cert. Conc.	Meas. Conc.	%Rec.	Cert. Conc.	Meas. Conc.	%Rec.	Cert. Conc.	Meas. Conc.	%Rec.
RTC CRM-021	24.8	ND	NA	586	1135	193.5	4792	2908	60.7	144742	149947	103.6	546	224	40.9
RTC CRM-020	397	429	92.5	22.3	ND	NA	753	583	77.4	5195	3444	66.3	3022	3916	129.6
BCR CRM 143R	--	--	--	--	--	--	131	105	80.5	180	206	114.8	1055	1043	99.0
BCR CRM 141	--	--	--	--	--	--	32.6	ND	NA	29.4	ND	NA	81.3	ND	NA
USGS GXR-2	25.0	ND	NA	2240	2946	131.5	76.0	106	140.2	690	742	107.6	530	596	112.4
USGS GXR-6	330	294	88.9	1300	2581	198.5	66.0	ND	NA	101	80.9	80.1	118	ND	NA
NIST 2711	105	104	99.3	726	801	110.3	114	ND	NA	1162	1172	100.9	350	333	94.9
NIST 2710	626	722	115.4	707	782	110.6	2950	2834	96.1	5532	5420	98.0	6952	6476	93.2
NIST 2709	17.7	ND	NA	968	950	98.1	34.6	ND	NA	18.9	ND	NA	106	98.5	93.0
NIST 2704	23.4	ND	NA	414	443	107.0	98.6	105	106.2	161	167	103.5	438	427	97.4
CNRC PACS-1	211	143	67.7	--	772	NA	452	302	66.9	404	332	82.3	824	611	74.2
SARM-51	--	--	--	335	466	139.1	268	373	139.2	5200	7199	138.4	2200	2676	121.6
SARM-52	--	--	--	410	527	128.5	219	193	88.1	1200	1107	92.2	264	215	81.4

Source: Ref. 4. These data are provided for guidance purposes only.

^a All concentrations in milligrams per kilogram.

%Rec.: Percent recovery; ND: Not detected; NA: Not applicable.

-- No data.

TABLE 8

EXAMPLE REGRESSION PARAMETERS FOR COMPARABILITY¹

	Arsenic				Barium				Copper			
	n	r ²	Int.	Slope	n	r ²	Int.	Slope	n	r ²	Int.	Slope
All Data	824	0.94	1.62	0.94	1255	0.71	60.3	0.54	984	0.93	2.19	0.93
Soil 1	368	0.96	1.41	0.95	393	0.05	42.6	0.11	385	0.94	1.26	0.99
Soil 2	453	0.94	1.51	0.96	462	0.56	30.2	0.66	463	0.92	2.09	0.95
Soil 3	—	—	—	—	400	0.85	44.7	0.59	136	0.46	16.60	0.57
Prep 1	207	0.87	2.69	0.85	312	0.64	53.7	0.55	256	0.87	3.89	0.87
Prep 2	208	0.97	1.38	0.95	315	0.67	64.6	0.52	246	0.96	2.04	0.93
Prep 3	204	0.96	1.20	0.99	315	0.78	64.6	0.53	236	0.97	1.45	0.99
Prep 4	205	0.96	1.45	0.98	313	0.81	58.9	0.55	246	0.96	1.99	0.96

	Lead				Zinc				Chromium			
	n	r ²	Int.	Slope	n	r ²	Int.	Slope	n	r ²	Int.	Slope
All Data	1205	0.92	1.66	0.95	1103	0.89	1.86	0.95	280	0.70	64.6	0.42
Soil 1	357	0.94	1.41	0.96	329	0.93	1.78	0.93	—	—	—	—
Soil 2	451	0.93	1.62	0.97	423	0.85	2.57	0.90	—	—	—	—
Soil 3	397	0.90	2.40	0.90	351	0.90	1.70	0.98	186	0.66	38.9	0.50
Prep 1	305	0.80	2.88	0.86	286	0.79	3.16	0.87	105	0.80	66.1	0.43
Prep 2	298	0.97	1.41	0.96	272	0.95	1.86	0.93	77	0.51	81.3	0.36
Prep 3	302	0.98	1.26	0.99	274	0.93	1.32	1.00	49	0.73	53.7	0.45
Prep 4	300	0.96	1.38	1.00	271	0.94	1.41	1.01	49	0.75	31.6	0.56

Source: Ref. 4. These data are provided for guidance purposes only.

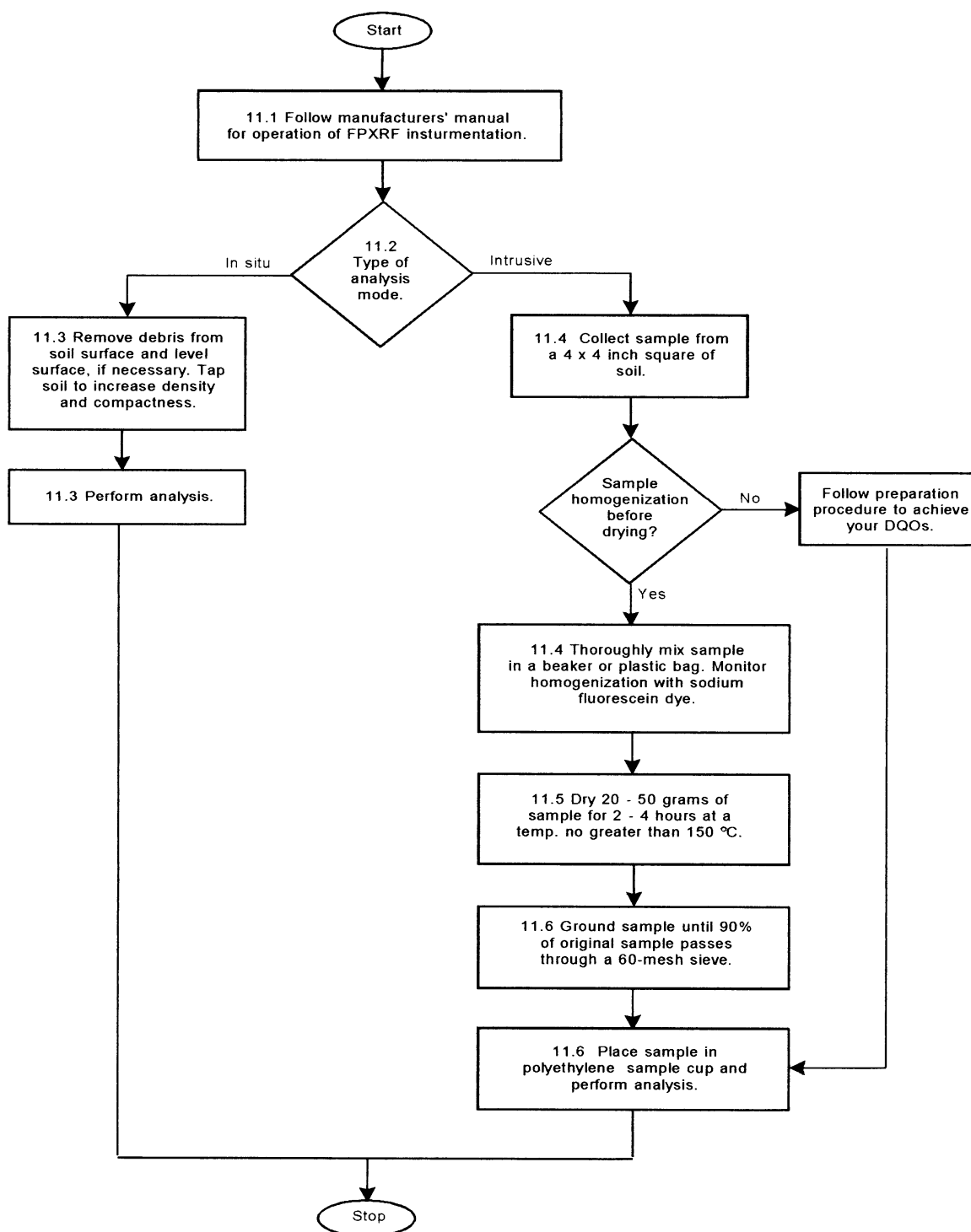
¹ Log-transformed data

n: Number of data points; r²: Coefficient of determination; Int.: Y-intercept

— No applicable data

METHOD 6200

FIELD PORTABLE X-RAY FLUORESCENCE SPECTROMETRY FOR THE DETERMINATION OF ELEMENTAL CONCENTRATIONS IN SOIL AND SEDIMENT



Appendix D

Tetra Tech and HM Environmental
Services Health and Safety Plan

U.S. Department of
Homeland Security

United States
Coast Guard



United States Coast Guard Health and Safety Plan for Soil Removal Activities

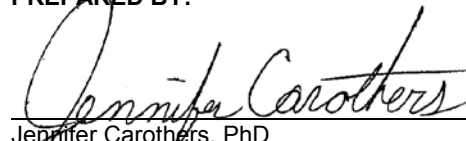
**Atwater Facility
Detroit, Michigan**

November 2012



United States Coast Guard
Health and Safety Plan for
Soil Removal Activities
Atwater Facility
Detroit, Michigan

PREPARED BY:

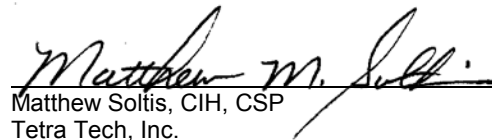


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1.0 INTRODUCTION

The objective of this Health and Safety Plan (HASP) is to provide the minimum safety practices and procedures to Tetra Tech personnel conducting soil removal and associated activities at the United States Coast Guard Atwater Facility at 2660 East Atwater Street, located in Detroit, Michigan.

This HASP has been developed using the latest available information regarding potential physical, chemical, or natural hazards associated with the proposed work and site. The HASP will be modified if new information becomes available. The changes to the HASP will be made by the Project Health & Safety Officer (PHSO) and approved by the Tetra Tech Health and Safety Manager (HSM) and the Project Manager (PM). The PM will notify affected personnel of the changes.

The elements of this HASP are in compliance with the requirements established by the Occupational Safety and Health Administration (OSHA) 29 Code of Federal Regulations (CFR) 1910.120 "Hazardous Waste Operations and Emergency Response" (HAZWOPER).

1.1 KEY PROJECT PERSONNEL AND ORGANIZATION

This section defines responsibility for site safety and health for Tetra Tech and subcontractor employees engaged in onsite activities. Personnel assigned to these positions will exercise the primary responsibility for onsite health and safety. The following persons will be the primary points of contact for questions regarding the safety and health procedures and the selected control measures that are to be implemented for onsite activities:

- The Tetra Tech PM is responsible for the overall direction of health and safety for this project.
- The PHSO is responsible for developing this HASP in accordance with applicable OSHA regulations. Specific responsibilities include:
 - Providing information regarding physical hazards associated with the site
 - Determining emergency response procedures and emergency contacts
 - Stipulating training requirements and reviewing appropriate training
 - Providing standard work practices to minimize potential
 - Modifying this HASP, as it becomes necessary
- The Tetra Tech Field Operations Leader (FOL) is responsible for implementation of the HASP with the assistance of an appointed SSO. The FOL manages field activities, executes the work plan, and enforces safety procedures as applicable to the work plan.

- The Site Safety Officer (SSO) supports site activities by advising the FOL on the aspects of health and safety on site. These duties may include:
 - Coordinating health and safety activities with the FOL.
 - Selecting, applying, inspecting, and maintaining personal protective equipment.
 - Establishing work zones and control points in areas of operation.
 - Implementing Hazard Communication, and other associated health and safety programs as they may apply to site activities.
 - Coordinating emergency services.
 - Providing site-specific training for onsite personnel.
 - Investigating accidents and injuries (see Attachment I - Incident Report Form)
 - Providing input to the PHSO regarding the need to modify this HASP, or applicable health and safety associated documents as per site-specific requirements.
- The Employer Designated “Competent Person” is responsible for **all** aspects of excavation safety as detailed in the OSHA Health & Safety Construction-Related Regulations - P - 650 to 699 - Subpart P - Excavations. This includes all Pre-Excavation Activities, Excavation Activities, and Post Excavation Activities (see Section 5.2).
 - Competent Persons Qualifications:
 - The employer designates Competent Person(s) based on knowledge and training.
 - Capable of identifying existing or predictable hazards associated with excavated cuts or cavities in the earth.
 - Has the authority to take prompt action to abate these hazards.
 - Working knowledge of Soil Analysis/Soil Classification.
 - Knowledgeable in the area of Protective Systems.
 - Working knowledge of the requirements of 29 CFR 1926 Subpart P.
 - 30 hour OSHA Construction Training and 10 hour OSHA Excavation training.
 - This position will typically be filled by Site Safety Officer (SSO), Field Operations Leader (FOL), or a Registered Professional Engineer (PE). The Excavation Competent Person must be specifically identified to handle this responsibility prior to work beginning in the specified space provided (Section 1.3) in this HASP.
- Compliance with the requirements stipulated in this HASP is monitored by the SSO and coordinated through the Tetra Tech HSM.

1.1.1 Stop Work Authority Policy

Employees are empowered, authorized, and responsible to stop work at any time when an imminent and uncontrolled safety or health hazard is perceived. In a Stop Work event (immediately after the involved task has been shut down and the work area has been secured in a safe manner) the employee shall contact the Project Manager and the Corporate Health and Safety Manager. Through observations and communication, all parties involved shall then develop, communicate, and implement corrective actions necessary and appropriate to modify the task and to resume work.

Note: In some cases one person may be designated responsibilities for more than one position. For example, the FOL may also be responsible for SSO duties.

1.2 **SITE INFORMATION AND PERSONNEL ASSIGNMENTS**

Site Name: East Atwater Street **Address:** Detroit, Michigan

Site Point of Contact: Lynn Keller **Phone Number:** 216.902.6258

Purpose of Site Visit: soil removal and associated activities

Proposed Dates of Work: November 2012 through completion

Project Team:

Tetra Tech Personnel:	Discipline/Tasks Assigned:
Joe Logan	Project Manager (PM)
TBD	Field Operations Leader (FOL)
TBD	Technical Expert
Matthew M. Soltis, CIH, CSP	Health and Safety Manager (HSM)
Jennifer Carothers, PhD	Project Health and Safety Officer (PHSO)
TBD	Site Safety Officer (SSO)
TBD	Excavation Competent Person

Subcontractor Personnel:	Discipline/Tasks Assigned:

Hazard Assessment (for purposes of 29 CFR 1910.132) for HASP preparation has been conducted by:

Prepared by: Jennifer Carothers, PhD

2.0 EMERGENCY ACTION PLAN

2.1 INTRODUCTION

This section has been developed as part of a planning effort to direct and guide field personnel in the event of an emergency. However, given the nature and scope of planned site activities, significant emergency situations are unlikely. In the event of an emergency, Tetra Tech personnel will provide emergency response support only to the capabilities of on-site personnel. Emergency situations that are beyond the capabilities of on-site Tetra Tech personnel will require assistance from outside emergency responders. In the event of emergencies that are beyond the capabilities of on-site personnel, an evacuation will be initiated. In an evacuation, site personnel will move to a safe place of refuge and the appropriate emergency response agencies will be notified. The emergency response agencies listed in Table 2-1 of this plan are capable of providing the most effective response, and as such, will be designated as the primary responders. These agencies are located within a reasonable distance from the areas of site operations, which ensures adequate emergency response time. This emergency action plan conforms to the requirements of OSHA Standard 29 C FR 1910.38(a), as allowed in OSHA 29 CFR 1910.120(I)(1)(ii).

Tetra Tech personnel will, through the necessary actions, provide incidental response measures for incidents such as:

- Incipient Fire and spill prevention and response
- Removal of personnel from emergency situations
- Provision of initial medical support for injury/illnesses requiring only first-aid level support
- Provision of site control and security measures, as necessary

2.2 EMERGENCY PLANNING

Through the initial hazard/risk assessment effort, there is very minor potential for injury or illnesses resulting from exposure to chemical, physical, or other hazards, and subsequently little likelihood of emergency situations. To further minimize or eliminate potential emergency situations, pre-emergency planning activities associated with this project will be implemented. The FOL is responsible for:

- Coordinating response actions with Detroit Emergency Services personnel, if available, to ensure that Tetra Tech emergency action activities are compatible with existing facility emergency response procedures.
- Identifying a chain of command for emergency action.

- Educating site workers to the hazards and control measures associated with planned activities at the site, and providing early recognition and prevention, where possible.

2.3 EMERGENCY RECOGNITION AND PREVENTION

2.3.1 Recognition and Prevention

Potential hazards, associated with this activity and the recommended control methods are discussed in detail in Sections 5.0 and 6.0 of this document. Additionally, early recognition will be supported by site surveys to eliminate any conditions that may predispose site personnel or properties to an emergency. The FOL will be responsible for these periodic surveys.

The above actions will provide early recognition for potential emergency situations. Should an incident take place, Tetra Tech will take initial defensive and offensive measures to control these situations. However, if the FOL and/or the SSO determine that an incident has progressed beyond the capabilities of site workers, Tetra Tech will withdraw and notify the appropriate response agencies.

Tetra Tech and subcontractor personnel will minimize the potential for emergencies by ensuring compliance with the HASP and through site surveys of work areas. Daily safety meetings will be conducted to cover important safety issues. The meetings shall be documented, including the date, attendance, subjects discussed, and names of individual(s) who conducted the meeting. Documentation shall be maintained in the site FOL or health and safety log book and copies furnished to the designated USCG authority on request.

2.4 SAFE DISTANCES AND PLACES OF REFUGE

In the event that the site must be evacuated, personnel will immediately stop activities and report to the FOL at the place of safe refuge. Safe places of refuge will be determined and communicated to the field crew prior to commencement of site activities. This information will be conveyed to personnel as part of the daily safety meeting conducted each morning. Upon reporting to the refuge location, personnel will remain there until directed otherwise by the Tetra Tech FOL. The FOL or the SSO will take a head count at this location to confirm the location of site personnel. The site logbook will be used to record the head count.

Once an evacuation is initiated, personnel will proceed immediately to the designated place of refuge, by the most direct route without further jeopardizing the welfare of workers.

2.5 EMERGENCY ALERTING AND ACTION/RESPONSE PROCEDURES

Since Tetra Tech personnel will be working in close proximity to each other, voice commands will comprise the mechanisms to alert site personnel of an emergency. If an incident occurs, site personnel will initiate the following procedures:

- Initiate incident alerting procedures (if needed) verbally.
- Describe to the FOL (who will serve as the Incident Coordinator) what has occurred and provide as many details as possible.
- If the FOL determines that the situation is beyond the capabilities of the site personnel emergency services will be contact using the emergency reference information listed in Table 2-1. Explain the situation and the appropriate emergency services will be dispatched. **Stay on the phone and follow the instructions of the emergency contact.**

2.6 EMERGENCY CONTACTS

Prior to initiating field activities, personnel will be thoroughly briefed on the emergency procedures to be followed in the event of an accident. Table 2-1 provides a list of emergency contacts and their associated telephone numbers. This table is readily available to site personnel.

**TABLE 2-1
EMERGENCY REFERENCE
DETROIT ATWATER**

AGENCY	TELEPHONE
Detroit Police/Fire/Rescue Services	911
Henry Ford Hospital	(313)-874-2839
Police	911
Fire Department	911
USCG Site Contact Lynn M. Keller, PMP	(216) 902-6258
Poison Control Center	(800) 222-1222
Michigan State One-Call (utility clearance)	(800)-482-7171
Chemtrec	(800) 424-9300
National Response Center	(800) 424-8802
Michigan DEQ (spill reporting)	800-292-4706
Project Manager Joe Logan	(412) 921-7231
Field Operations Leader, TBD	
Tetra Tech, Pittsburgh Office	(412) 921-7090
Health and Safety Manager Matthew M. Soltis, CIH, CSP	(412) 921-8912
Project Health and Safety Officer Jennifer Carothers, PhD	(412) 921-8083

2.7 EMERGENCY ROUTE TO HOSPITAL

The closest hospital with an emergency room to East Atwater Street is Henry Ford Hospital. An area map showing the proximity of this site to the hospital is incorporated into this HASP as Figure 2-1. Directions are as follows:

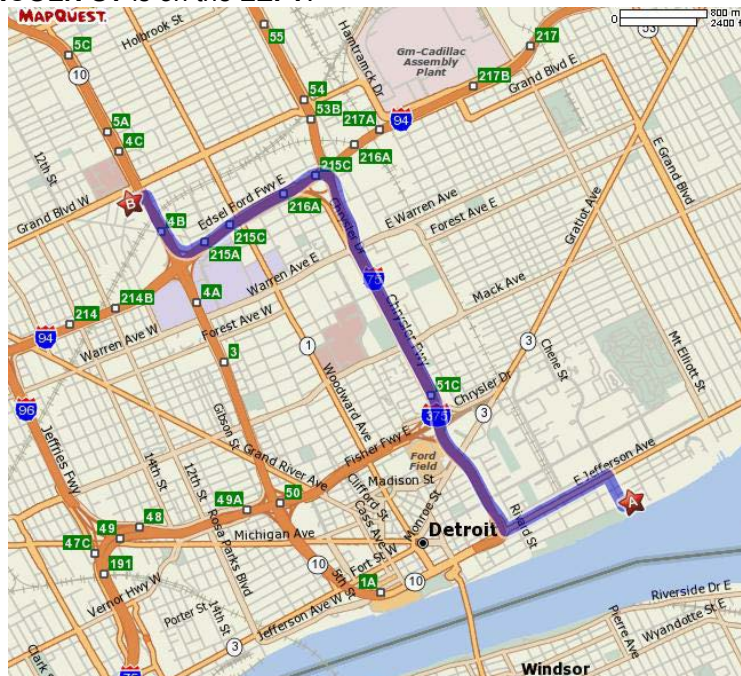
Henry Ford Hospital (Emergency Room)
6503 Lincoln St.
Detroit, Michigan 48202
(313)-874-2839

**FIGURE 2-1
HOSPITAL ROUTE**

Total Travel Estimates: 10 minutes / 5.46 miles

A: 2660 Atwater St, Detroit, MI 48207-4418

- | | | |
|-----|--|--------|
| 1: | Start out going SOUTHWEST on E ATWATER ST toward CHENE ST. | 0.1 mi |
| 2: | Turn RIGHT onto CHENE ST. | 0.2 mi |
| 3: | Turn LEFT onto E JEFFERSON AVE/JEFFERSON AVE E. | 0.8 mi |
| 4: | Turn RIGHT onto CHRYSLER DR. | 0.1 mi |
| 5: | Turn SLIGHT LEFT onto ramp. | 0.1 mi |
| 6: | Merge onto I-375 N/CHRYSLER FWY. | 0.6 mi |
| 7: | I-375 N/CHRYSLER FWY becomes I-75 N/CHRYSLER FWY. | 1.4 mi |
| 8: | Take EXIT 53B toward I-94/FORD FWY/PORT HURON/CHICAGO. | 0.4 mi |
| 9: | Merge onto I-94 W via the exit on the LEFT toward CHICAGO. | 1.0 mi |
| 10: | Take the M-10 N exit, EXIT 215B , toward SOUTHFIELD. | 0.3 mi |
| 11: | Merge onto MI-10 N/JOHN C LODGE FWY. | 0.2 mi |
| 12: | Take the MILWAUKEE AVE exit, EXIT 4C , toward W GRAND BLVD. | 0.2 mi |
| 13: | Turn LEFT onto MILWAUKEE ST W. | 0.1 mi |
| 14: | Turn RIGHT onto LINCOLN ST. | 0.0 mi |
| 15: | 6503 LINCOLN ST is on the LEFT. | 0.0 mi |



2.8 EMERGENCY MEDICAL TREATMENT

Tetra Tech personnel will perform removal of personnel from emergency situations and may provide initial medical support for injury/illnesses requiring only first-aid level support. Medical attention above that level will require assistance and support from the designated emergency response agencies.

2.9 INJURY/ILLNESS REPORTING

If any Tetra Tech personnel are injured or develop an illness as a result of working on site, the Tetra Tech "Injury/Illness Procedure" (Attachment I) must be followed. Following this procedure is necessary for documenting of the information obtained at the time of the incident.

Any pertinent information regarding allergies to medications or other special medical conditions will be provided to EMS personnel. This information is listed on Medical Data Sheets (Attachment II) that are completed by project personnel and are filed on-site. If an emergency situation occurs that involves a suspected exposure to a hazardous substance, provide available information on the chemical, physical, and toxicological properties of the chemical to EMS personnel.

2.10 PPE AND EMERGENCY EQUIPMENT

PPE normally available for the project (Level D) will also be available for use in case of an emergency or spill incident.

A first aid kit, eye wash units, and fire extinguishers will be maintained on-site and shall be immediately available for use in case of an emergency.

3.0 SITE BACKGROUND

Tetra Tech is under contract with the USCG is conducting a Removal Action (RA) for excavation and disposal of polynuclear aromatic hydrocarbons (PAHs), arsenic, and lead contaminated soil at the USCG Atwater Facility in Detroit, Michigan. The RA includes excavation and disposal of the contaminated soil.

The site is located at 2660 East Atwater Street, Detroit, Michigan. Activity on the USCG Atwater Facility property in Detroit, Michigan began prior to 1897. The property covers approximately 1.26 acres of riverfront land on Atwater Street in downtown Detroit, although only about 0.5 acre of the parcel is land. No buildings are currently on the site. The former maintenance building and garage were demolished around 2004. The site is predominantly covered with asphalt and concrete with a small grassy area. A fence with a locked gate is located along Atwater Street and a fence is located on the eastern and western sides of the property to restrict access to the site from adjacent properties.

4.0 SCOPE OF WORK

This section of the HASP addresses the proposed site activities to be conducted at the Atwater Facility as part of this project. This site-specific HASP provides information related to each of the tasks that are to be performed as part of the scope of work. If tasks other than those listed below are performed at the site, this and accompanying sections will have to be modified accordingly.

Site activities to be conducted at the Atwater Facility include the following:

- Mobilization and demobilization
- Removal of contaminated soil
 - Including Soil Transport and Disposal Management
- Site restoration
 - The excavation will be backfilled with clean fill and seeded
- Soil sampling
- XRF analysis
- Decontamination of sampling equipment
- Land survey

The above listing represents a summarization of the tasks as they apply to the scope and application of this HASP. For more detailed description of the associated tasks, please refer to the Site-Specific Work Plan. If additional tasks are determined to be necessary, this HASP will be amended and a hazard evaluation of the additional tasks performed.

5.0 TASKS/HAZARDS/ASSOCIATED CONTROL MEASURES

The purpose of this section is to identify the anticipated hazards and appropriate hazard prevention/hazard control measures that are to be observed for each planned task or operation. These topics have been summarized for each planned task through the use of task-specific Activity Hazard Analysis (AHAs), see Attachment III, which are to be reviewed in the field by the FOL/SSO with the task participants prior to initiating any task. Additionally, potential hazard and hazard control matters that are relevant but are not necessarily task-specific are addressed in the following portions of this section.

Section 6.0 presents additional information on hazard anticipation, recognition, and control relevant to the planned field activities.

5.1 GENERAL SAFE WORK PRACTICES

In addition to the task-specific work practices and restrictions identified in the AHAs attached to this HASP, the following general safe work practices are to be followed when conducting work on-site.

- Eating, drinking, chewing gum or tobacco, taking medication, or smoking in contaminated or potentially contaminated areas or where the possibility for the transfer of contamination exists is prohibited.
- Wash hands and face thoroughly upon leaving a contaminated or suspected contaminated area. If a source of potable water is not available at the work site that can be used for hands-washing, the use of waterless hands cleaning products will be used, followed by actual hands-washing as soon as practicable upon exiting the site.
- Avoid contact with potentially contaminated substances including puddles, pools, mud, or other such areas.
- Avoid kneeling on the ground or leaning or sitting on equipment.
- Keep monitoring equipment away from potentially contaminated surfaces.
- Plan and mark entrance, exit, and emergency evacuation routes.
- Rehearse unfamiliar operations prior to implementation.

- Buddies should maintain visual contact with each other and with other on-site team members by remaining in close proximity to assist each other in case of emergency.
- Establish appropriate safety zones including support, contamination reduction, and exclusion zones.
- Minimize the number of personnel and equipment in contaminated areas (such as the exclusion zone).
- Non-essential vehicles and equipment should remain within the support zone.
- Establish appropriate decontamination procedures for leaving the site.
- Immediately report injuries, illnesses, and unsafe conditions, practices, and equipment to the SSO.
- Observe co-workers for signs of toxic exposure and heat or cold stress.
- Inform co-workers of potential symptoms of illness, such as headaches, dizziness, nausea, or blurred vision.

5.2 EXCAVATION SAFE WORK PRACTICES

Skid-steer loaders have been selected for use because of their size and ability to accomplish the task with the least amount of environmental consequence. These safety features must not be bypassed, defeated or improperly maintained which will result in serious injury or death to the operator and/or other employees working on or around the equipment. The common safety features of a skid-steer loader include:

- Seatbelt for operator restraint
- Falling Object Protective Structure (FOPS)
- Roll-Over Protective Structure (ROPS)
- Control Interlock System

Excavation activities will be subcontracted with contractor oversight.

All the Tetra Tech Excavation Safety Procedures and the OSHA Health & Safety Construction-Related Regulations - P - 650 to 699 - Subpart P - Excavations must be adhered to.

The following information summarizes the main points of these procedures and regulations and is for Tetra Tech and subcontractor personnel awareness.

- Utility clearances must be in place prior to the beginning of excavation (in accordance with the Tetra Tech Utility Locating SOP in the Health and Safety Guidance Manual Section 7.0).
- Excavation boundaries must be demarcated with appropriate warning signs (e.g., construction activities in progress).
- Traffic patterns for equipment and the loading of trucks must be established. This pattern should form a loop to minimize backing, an activity which causes many accidents.
- Traffic patterns for foot and small vehicular traffic must keep workers away from heavy equipment.
- Traffic patterns for heavy equipment must be constructed to maintain traffic flow a minimum of 10 feet from unsupported walls or excavation boundaries.
- Excavation along thoroughfares will require the use of warning signs, barricades and flag-persons for alteration of traffic patterns, as necessary.
- Ground personnel should be provided with reflective vests to increase visibility and air horns to signal loud trucks and heavy equipment.
- Ground activities with heavy equipment must be supported with a ground spotter. The operators should be instructed that they are to follow the instructions provided by the ground spotter unless another party is otherwise authorized.
- Surface encumbrances within the intended work area of the excavation will be removed or supported, as necessary, in accordance with OSHA 1926.651(a).
- Prior to being put into service at the site, the excavator will be inspected by the SSO, and this inspection will be documented using the applicable forms in Attachment IV.
- Heavy equipment will be positioned and operated so that it never approaches closer than 4 feet from the edge of an open excavation (other than the boom and bucket portion of the excavator).

- A decontamination station should be established at the loading and off-loading areas to flush mud and dirt from the wheels and tires as well as any areas of the vehicle impacted during the loading operation.
- Tetra Tech personnel WILL NOT enter a trench past 4 feet deep.

The Tetra Tech Excavation Safety Procedures (in the Tetra Tech HSGM) can be referred to for more details.

5.3 X-RAY SAFE WORK PRACTICES

The general safe work practices for XRF Sampling are as follows:

The area where the device will be used will be identified using signs warning persons entering the area of the activities being conducted. The operator will ensure persons not critical to the operation are not in the area demarcated for this purpose.

The operator will insure good general housekeeping is practiced in the analytical area to control potential contamination within a confined space.

The operator will practice good work hygiene practices to minimize potential introduction of residual contamination into the body through hand to mouth contact.

The safe and proper operation of the Innov-X XRF instruments is the highest priority. These instruments produce ionizing radiation and should **ONLY** be operated by individuals, who have been trained and received a manufacturer's training certificate.

Radiation levels reported during testing are < 0.1 mR/hr on all surfaces of the analyzer except at or near the exit port for the radiation. This means that if an operator follows standard operating procedures, they will not obtain any detectable radiation dose above naturally occurring background radiation, on their hand while holding the analyzer, or on any area of their body.

Plug the battery charger into a grounded electrical outlet that is easily accessible at all times. Do not pull on cords and cables. When unplugging the cord from the electrical outlet, grasp and pull the cord by the plug.

Handle battery packs properly; do not: disassemble, crush, puncture, short external contacts, dispose of in fire or water, or expose a battery pack to temperatures higher than 60 °C (140 °F). Do not attempt to open or service a battery pack. Improper handling or charging may cause the battery to explode.

Keep all safe guards and warning labels in place

Safe Work Procedures:

1. **Proper Usage.** Never point the instrument at another person. Never hold a sample in your hand and test that part of the sample.
2. **Establish Controlled Areas.** The location of storage and use should be of restricted access to limit potential exposure to possible ionizing radiation. In use, the target should not be hand held and the area at least three paces beyond the target should be unoccupied.
3. **Specific Controls.** The instrument should be stored, in a locked case, or locked cabinets when not in use. When in use, it must remain in the direct control of a factory trained, certified operator.
4. **Time - Distance - Shielding Policies.** Operators should minimize the time around the energized instrument, maximize the distance from the instrument window during shots, and shoot into high density materials whenever possible. Under no circumstances should the operator point the instrument at themselves or others whether energized or not.
5. **Prevent Exposure to Ionizing Radiation.** - All reasonable measures, including labeling, operator training and certification, and the concepts of time, distance, & shielding, should be implemented to limit radiation exposure to as low as reasonably achievable (ALARA).

5.4 HEAVY EQUIPMENT SAFETY

Operation of heavy equipment such as excavators, loaders, graders, rollers, and bulldozers, will be done by operators who have demonstrated the ability and necessary skills to operate safely. Ground-based workers will be trained in how to work safely around the equipment, and how to stay clear. Unsafe practices by site personnel can create dangerous situations. Serious injuries can occur if the equipment strikes a worker, or if the equipment is rolled over. Here are a few common safety rules for operators and ground based workers to consider:

- Establish good communication system.

- A standardized set of hand signals will be used by the operator and signal person.
- Operators will always know exactly where all ground based workers are located,
- High visibility vests will be worn to help the operator to locate personnel quickly
- Back-up warning alarms must be functional so that it can be heard by all nearby workers.
- Two-way radios are also valuable communication tools.
- Heavy equipment must have a rollover protective structure (ROPS) meeting OSHA requirements.
 - ROPS is designed to protect the operator if the machine tips over.
 - A seat belt must be worn so that the operator will not be thrown out of the seat during a rollover or upset situation.
 - When working on slopes, avoid moving across the face of the slope.
 - Operate up and down the slope face if possible.
 - Use extreme caution when operating near open excavations.
- Wear hearing protection when required.
 - When you have to shout to be heard from 2 feet or less, use protective plugs or muffs.
- Never jump onto or off the equipment.
 - Operators will use the handles and steps following the three-point contact rule when climbing onto or off heavy equipment.
 - The three-point rule means having both feet and one hand, or one foot and both hands in contact with the ladder access at all times.
- Inspect and service the equipment regularly.
 - Complete equipment service in accordance with the manufacturer's recommendation.
 - Periodic safety inspections on all components of the equipment will be conducted by qualified personnel.
 - Use the heavy equipment inspection checklist found in Attachment IV of this HASP
- Perform pre-work area walk around inspection.
 - The operator will preview terrain in work area, place pin flags around boundary of equipment travel area or roadway boundaries.
 - Use a spotter to observe equipment movement and to alert operator to dangerous situations.
- Make sure the safety guards and covers are secure and in place.
- Only operate machine when site personnel and obstructions are cleared from area.

- Only the operator will ride on the machine.
- The operator must know the proper traffic pattern and obey the spotter.
- Park on level ground as much as possible with parking brake set when not in motion.
- Avoid operating too close to ditch banks or building overhangs
- When using machines equipped with elevating portions, such as forklift, dump truck, or backhoe, stay at least 10 feet away from high-voltage power lines.
- Be aware of color coded indicator flags for buried telephone and utility lines:

Red	electric power lines, cables, conduit, and lighting cables
Orange	telecommunication, alarm or signal lines, cables, or conduit
Yellow	natural gas, oil, steam, petroleum, or other gaseous or flammable material
Green	sewers and drain lines
Blue	drinking water
Violet	reclaimed water, irrigation, and slurry lines
Pink	temporary survey markings, unknown/unidentified facilities
White	proposed excavation limits or route

5.5 WATER HAZARDS

Planned activities involve locations that are near bodies or on bodies of water. Sampling activities will be conducted from a flat bottom motor boat. Other tasks, such as depth measurement, will be conducted from a canoe. To avoid potential hazards associated with working near water (drowning), the field team shall employ lifelines (tie-off procedure), safety harnesses, when within 4 feet of the waters edge. When working out of a canoe or other boat, U.S. Coast Guard (USCG) approved personal flotation devices (PFD) will be used. Due to the obvious hazards associated with working on or near waters edge during inclement weather, all field activities may be temporarily suspended or terminated at the discretion and direction of the FOL or SSO.

5.5.1 Safe Boating Practices

Offshore activities will require site personnel to work from boats/barges in bodies of water. To avoid potential hazards associated with working on water (drowning), the field team shall employ lifelines (tie-off procedure), safety harnesses, when on the barge. U.S. Coast Guard (USCG) approved personal flotation devices (PFD) will be on hand for all participants and will be used. Due to the obvious hazards associated with working on water during inclement weather, field activities may be temporarily suspended or terminated at the discretion and direction of the FOL or SSO.

Refer to the Tetra Tech Boat Safety Checklist in Attachment V of this HASP.

U.S.C.G. Flotation Device Types

Use the following information to determine the proper type of U.S.C.G. PFD.

Off Shore Life Jacket (Type I, 22lbs buoyancy)

Type I life jacket is the best choice for rough or open waters. This type will float you the best and is favorable if rescue may be long in coming. This type will turn an unconscious person upright in the water. Though is bulky it does have a highly visible color for easier detection.

Near Shore Buoyant Vest (Type II, 15.5lbs buoyancy)

Type II is a good choice for calmer waters. It will turn most unconscious persons face-up in the water. Though it is less bulky than Type I, it is not intended for long hours in calm or rough water.

Flotation Aid (Type III, 15.5lbs buoyancy)

Type III is probably the most comfortable device offering more freedom of movement, such as water skiing or fishing, but is not intended for rough water. Also, an unconscious person may end up face-down in the water.

Throwable Devices (Type IV)

Throwable devices are intended for calm waters with heavy boat traffic where help is always close. It is not intended for unconscious persons or non-swimmers or long hours in the water. They are good backups for the other devices.

Site personnel shall wear Type III personal flotation devices in the event someone falls overboard, boats sinks or capsizes. Type IIIs were selected as they offer the most flexibility for working while still meeting minimum requirements for buoyancy. In situations where personal flotation devices cannot be worn due to the task to be conducted, the flotation devices shall be immediately available/accessible. It is recommended that personal flotation devices be continually worn during colder months due to the potential for hypothermia to restrict muscle movement and therefore, self-rescue and maintaining buoyancy. In addition, a single Type IV Throwable Flotation Device shall be maintained on board the boat with at least 90 feet of 3/8 polypropylene line.

When work activities take personnel within four feet of navigable waters edge per sonnel will have immediately accessible a lifeline with a throwing bag or Type IV flotation device facilitate extraction from the water. Personnel working on water's edge will do so using the buddy system to assist in rescue efforts, if needed.

Device	Type	Description
Off Shore Life Jacket	Type I 22lbs buoyancy	Best in rough or open waters. Floats best especially in long time rescue. Will turn unconscious upright. Bulky but highly visible.
Near Shore Buoyant Vest	Type II, 15.5lbs buoyancy	Good in calmer waters. Will turn most unconscious face-up. Less bulky. Not for long time rescue.
Flotation Aid	Type III 15.5lbs buoyancy	Most comfortable device offering more freedom of movement. Not intended for rough water. Unconscious may end up face-down
Throwable Devices	Type IV	Throwable devices for calm waters with heavy boat traffic where help is always close. Not for unconscious, non-swimmers or long hours. Good backups for the other devices.

U.S.C.G Boat Regulations

No person born on or after January 1, 1986 shall operate a vessel that is fitted with propulsion machinery of more than ten (10) horsepower on waterways unless the person has successfully completed a boating safety education program as approved by the director of the Department of Environmental Management. Certain bodies of water in some states may also have local restrictions as to type and size of watercraft or motor horsepower, restricted use areas, boat speed, and times for use. The FOL is responsible for checking with appropriate local authorities to identify and address any additional requirements/restrictions.

The U.S.C.G. requires boats to have the following equipment on board:

- One personal flotation device per person
- A sound producing device such as an air horn or whistle which can be heard one half mile.

Speed Limits

Any motorboat or vessel operated within a harbor or inlet or any pond of other confined body of water shall not exceed 45 mph from sunrise to sunset and 25 mph during periods of darkness or restricted visibility. Lower speed limits may be regulated in certain areas.

Reckless and Negligent Operation

Negligent or grossly negligent operation of a vessel which endangers lives and/or property is prohibited by law. A civil penalty may be imposed by the Coast Guard for this offense under federal laws. An operator may be subjected to a fine of up to \$5,000 and or imprisonment for up to one year, or both. The Maryland penalty is a fine of up to \$500 for the first offense.

Some examples of actions that may constitute negligent or grossly negligent operation include but are not limited to:

- Operating in a swimming area
- Operating under the influence of alcohol or drugs.
- Excessive speed in the vicinity of other boats or in dangerous waters.
- Hazardous water skiing practices
- Bowriding, also riding on seatback, gunwale or transom.

Termination of Use

A state Natural Resources Police Officer who observes a boat being operated in an unsafe condition and who determines that an especially hazardous condition exists may direct the operator to take immediate steps to correct the condition, including returning to port. Termination for unsafe use may be imposed for, but is not limited to:

- Insufficient number of USCG approved Personal Flotation Devices.
- Insufficient fire extinguishers.
- Overloading beyond manufacturer's recommended safe loading capacity.
- Improper navigation light display.
- Ventilation requirements for tank and engine spaces not met.
- Fuel leakage.
- Fuel in bilges.
- Improper backfire flame control.

Boating Accident Reports

The operator of any boat involved in an accident must stop, render assistance, and offer identification. An accident report must be made to the Department within 48 hours if:

- A person dies within 24 hours;
- A person loses consciousness or receives medical treatment beyond first aid or is disabled more than 24 hours;
- A person disappears from the vessel under circumstances that indicate death or injury.

Accidents must be reported within 10 days if damage to all vessels and other property totals more than \$500.00 or an earlier report is not required. Running aground or hitting a fixed or floating object is considered a boating accident. Accident reports are required by federal law and furnish information for use in accident prevention. Information from individual reports will not be publicly disclosed nor may the information be used in court.

Rendering Assistance

Federal law requires the operator of a vessel to provide assistance, that can be safely provided to any individual in danger on the water. Persons who fail to provide assistance may be subject to fine or imprisonment.

Vessels Required to be Registered

All vessels, whether commercial or recreational, must be registered in the respective state if it is equipped with any kind of primary or auxiliary mechanical propulsion; if it is not currently documented with the U. S. Coast Guard. An owner of a federally documented vessel, though exempt from state numbering requirements, shall apply to the appropriate state department for documented use decals, and is subject to the state excise tax requirements.

6.0 HAZARD ASSESSMENT

The following section provides information regarding the chemical, physical, and natural hazards anticipated to be present during the activities to be conducted.

6.1 CHEMICAL HAZARDS

The potential health hazards associated with the site include inhalation and ingestion of various contaminants that may be present. There is limited sampling data collected from some sites. Based on sampling and historic information lead has been identified as the contaminant of concern.

The data presented in Table 6-1 indicate that significantly dusty conditions (i.e., enough dust to obscure vision over a very short distance of only a few feet) would have to be generated before any lead exposure concern via inhalation would be encountered. Based on the nature of the planned activities and on anticipated site conditions, it is very unlikely that workers will encounter dust concentrations approaching the level presented in Table 6-1.

TABLE 6-1
COMPARISON OF WORST-CASE LEAD AIR CONCENTRATIONS
WITH CURRENT OCCUPATIONAL EXPOSURE LIMITS

Contaminant of Concern	Maximum Detection in Soil Sampling	Amount of Dust-in-Air that would have to be generated before PEL/TLV would be reached	Current Occupational Exposure Levels (OELs)
PAHs (benzo-a-pyrene)	4510 ug/kg	NA	NA
Arsenic	24 mg/kg	104.17 mg/m ³	OSHA: 0.5 mg/m ³ , TWA ₈
Lead	2,100 mg/kg	5.21 mg/m ³	OSHA: 0.05 mg/m ³ , TWA ₈ NIOSH 0.05 mg/m ³ , TWA ₈

Table Notes:

TWA₈: Average air concentration over an 8-hour work period that is not to be exceeded

2 mg/m³ – Visible dust

6.1.1 Lead Properties and Exposure Signs/Symptoms

In its pure state, lead is a heavy, ductile, soft gray solid. Severe symptoms of acute lead poisoning can include seizures, unconsciousness, paralysis, or swelling in the brain. Most lead poisoning comes from low levels of exposure over a long period of time. The major organ systems affected are the central nervous system, gastrointestinal tract, and the renal system. Neurological effects may include poor coordination, weakness in hands and feet, headaches, seizures, paralysis, and coma. Gastrointestinal symptoms may include stomach aches, cramping, constipation, or diarrhea, nausea and vomiting. Other symptoms include persistent, unexplained fatigue, headache, muscle weakness, and higher rates of tooth

decay. The principle routes that a worker could be exposed to this contaminant of concern COC include inhalation, ingestion, and direct skin contact. These potential exposure routes and the means that will be used to prevent or control them are addressed below.

6.1.2 Polycyclic Aromatic Hydrocarbons (PAHs)

PAHs are a group of over 100 different chemicals that are formed during the incomplete burning of coal, oil and gas, garbage, or other organic substances like tobacco or charbroiled meat. PAHs are usually found as a mixture containing two or more of these compounds, such as soot.

Some PAHs are manufactured. These pure PAHs usually exist as colorless, white, or pale yellow-green solids. PAHs are found in coal tar, crude oil, creosote, and roofing tar, but a few are used in medicines or to make dyes, plastics, and pesticides.

Exposure to polycyclic aromatic hydrocarbons usually occurs by breathing air contaminated by wild fires or coal tar, or by eating foods that have been grilled. PAHs have been found in at least 600 of the 1,430 National Priorities List sites identified by the Environmental Protection Agency.

PAHs have the potential to cause harmful effects on the skin, body fluids, and ability to fight disease after both short- and long-term exposure.

6.1.3 Arsenic

Breathing high levels of inorganic arsenic can give you a sore throat or irritated lungs.

Ingesting very high levels of arsenic can result in death. Exposure to lower levels can cause nausea and vomiting, decreased production of red and white blood cells, abnormal heart rhythm, damage to blood vessels, and a sensation of "pins and needles" in hands and feet.

Ingesting or breathing low levels of inorganic arsenic for a long time can cause a darkening of the skin and the appearance of small "corns" or "warts" on the palms, soles, and torso.

Skin contact with inorganic arsenic may cause redness and swelling.

6.1.4 Inhalation

In regarding the results of this data evaluation, it is important to recognize the following:

- The soil value used in this evaluation was the highest concentration previously detected in the soil.

- The amount of dust-in-air that would have to be generated before OEL would be reached OEL is greater than the level of visible dust.
- The planned work area is outdoors, with ample natural ventilation that will reduce any airborne concentrations through dilution and dispersion.
- To control dust containing metals, area wetting efforts will be used to keep dust levels down.

As a result of these factors, it is very unlikely that workers participating in this activity will encounter any airborne concentrations of the COCs that would represent an inhalation exposure concern. The use of common dust suppression methods should be adequate to maintain airborne concentrations of all soil contaminants below levels of concern.

6.1.5 Ingestion and Skin Contact

Potential exposure concerns to COCs may also occur through ingesting or coming into direct skin contact with contaminated media. However, the likelihood of worker exposure concerns through these two routes is also considered very unlikely, provided that workers follow good personal hygiene, proper sample collection/sample handling practices, and wear appropriate PPE as specified in this HASP. Examples of onsite practices that are to be observed that will protect workers from exposure via ingestion or skin contact include the following:

- No hand-to-mouth activities on site (eating, drinking, smoking, etc.)
- Washing hands upon leaving the work area and prior to performing any hand to mouth activities
- Wearing surgeon's-style gloves whenever handling potentially-contaminated media, including groundwater, bailing tools, and sample containers.

6.2 PHYSICAL HAZARDS

In addition to the chemical hazards identified, physical hazards that may also be present include the following:

- Heavy equipment hazards
- Ambient temperature extremes (cold stress)
- Pinches and compressions
- Heavy lifting or working in awkward postures (muscle strains and pulls)

- Slips, trips, and falls (uneven or unstable terrain)
- Insect/animal bites/stings

These physical hazards and their applicability to each site task are discussed in detail in the Safe Work Permits. Additionally, each of these physical hazards is discussed in greater detail in the Health and Safety Guidance Manual. Specific discussions on some of these hazards are presented below.

6.2.1 Strain/Muscle Pulls from Heavy Lifting

During execution of planned activities there is some potential for strains, sprains, and/or muscle pulls due to the physical demands and nature of this site work. To avoid injury during lifting tasks personnel are to lift with the force of the load carried by their legs and not their backs. When lifting or handling heavy material or equipment use an appropriate number of personnel. Keep the work area free from ground clutter to avoid unnecessary twisting or sudden movements while handling loads.

6.2.2 Vehicular and Equipment Traffic

Hazards associated with vehicular and equipment traffic may exist during site activities. To minimize the potential for injuries associated with potential vehicular hazards, site personnel will be instructed to maintain awareness of traffic and moving equipment when performing site activities. When working near roadways, site personnel will wear high visibility vests.

6.2.3 Inclement Weather

Project tasks under this Scope of Work will be performed outdoors. As a result, inclement weather may be encountered. In the event that adverse weather conditions arise (electrical storms, hailstorms, etc.), the FOL and/or the SSO will be responsible for temporarily suspending or terminating activities until hazardous conditions no longer exist.

Each of these physical hazards is discussed in the Health and Safety Guidance Manual. Additionally, information on these physical hazards and their associated control measures are discussed in the Safe Work Permits.

6.2.4 Temperature Extremes (Heat Stress and Cold Stress)

Given the anticipated project schedule, encountering extremely high ambient temperatures during the planned work could be encountered. Likewise, exposures to extremely cold temperatures could be encountered due to the geographic location of the project site. If such conditions are encountered,

information on heat and cold stress recognition, prevention, and control may be found in Section 4.6 of the Health & Safety Guidance Manual.

6.2.5 Heavy Equipment/Excavation Hazards

Utility clearances must be in place prior to the beginning of excavation (in accordance with the Tetra Tech Utility Locating SOP in the Health and Safety Guidance Manual Section 7.0).

The Excavation Competent Person identified in this HASP is responsible to address heavy equipment and excavation safety matters on this project (see Section 5 for details).

6.2.6 Noise in Excess of 85 dBA

Worker exposure to noise that can approach hazardous levels is a common potential hazard on most project work sites. Workers who must work in areas or who must perform operations where noise levels can approach an 8-hour time weighted average of 85 decibels on the A-weighted scale (dBA) must have received hearing conservation training within the past 12 month period (this is normally provided as part of the 8-hour refresher training). If personnel have not had this training within the last 12 months they will be provided such training by the SSO at the project site prior to participating in high noise level activities. On this project, high noise levels may be encountered when working near the drill rig, and during decontamination operations when using a pressure washer,

As a general rule-of-thumb to prevent worker exposure to high noise levels, workers will be informed to observe the following:

- If ambient noise levels are loud enough that they have to raise their voice in order to communicate with another person who is less than two feet away, hearing protection will be required.

Also, if any existing site operations are posted as high noise areas or that hearing protection is required in that area, then hearing protection will be used.

Hearing protection will be the primary control measure for personnel who must work within the vicinity of excessive noise levels.

6.2.7 Contact with Energized Systems

Contact with energized sources can result in severe injury and even death. There are two areas of concern with this potential hazard: contact with energized processing equipment and contact with

energized utilities including underground utilities (including electrical transmission lines, gas lines, water lines, etc.) and overhead utilities (i.e., power lines).

- Use and application of the Tetra Tech Standard Operating Procedure (SOP) for Utility Locating and Excavation Clearance found in the Tetra Tech Health and Safety Guidance Manual will be employed. This procedure provides step-by-step instructions for clearance of underground utilities, as well as avoidance techniques, and required documentation.
- Establishment of a suitable clearance distance (20-feet) from overhead utilities will be the primary method to control hazards conveyed through contact with these power sources.

6.3 NATURAL HAZARDS

Insect/animal bites and stings, poisonous plants, and inclement weather are natural hazards that may be present given the location of activities to be conducted. In general, avoidance of areas of known infestation or growth will be the preferred exposure control for insects/animals and poisonous plants. Specific discussion on principle hazards of concern follows:

6.3.1 Insect Bites and Stings

In an effort to minimize this hazard the following control measures will be initiated where possible:

- Loose fitting clothing with long sleeves, where possible (given heat stress considerations) should be employed to provide a barrier between the field person and the insects.
- Commercially available bug sprays and repellents can be used if necessary.
- Products should be applied per manufacturer instructions.
- For mosquito infested areas mosquito nets may also be used.
- The FOL and/or the SSO will preview access routes and work areas in an effort to identify physical hazards including nesting areas in and around the work sites.
- These areas will be communicated to site personnel.

Note: It is important that allergies be reported on the Medical Data Sheets and to the SSO. Additionally, specific procedure for administering treatment as directed by your physician must also be communicated to make sure the quickest and most efficient response possible.

If you are allergic, medications and/or antidotes should be maintained on hand. Over the counter medication such as Benadryl can provide relief until medical attention can be secured.

6.3.2 Vector (Ticks, Mosquitoes, etc.) Transmitted Illnesses and Diseases

Ticks and mosquitoes, in this case, are the primary vectors of concern. These insects have been identified in the transmission of various diseases, including Lyme's disease and malaria. Warm months (spring through early fall) are the predominant time for this hazard to impact personnel. Information concerning vector transmitted Lyme's Disease including recognition, evaluation, tick removal, and control is provided in Section 4.0 of the Health and Safety Guidance Manual.

West Nile Virus

People are infected with the WNV as a result of the bite of the Northern House Mosquito. Mosquitoes acquire the virus from infected birds and horses and then transmit the virus to people and other animals. West Nile Encephalitis cases occur primarily in the late summer or early fall.

West Nile encephalitis is caused by a virus transmitted to humans by mosquitoes. WNV is commonly found in Africa, West Asia, and the Middle East. It is closely related to St. Louis encephalitis virus found in the United States. The West Nile-like virus that has been found in United States is genetically related to WNV, but because of genetic differences it may be a new subtype of WNV.

The mosquito becomes infected by feeding on birds infected with the WNV. Infected mosquitoes then transmit the WNV to humans and animals when biting (or taking a blood meal). West Nile encephalitis is NOT transmitted from person-to-person. There is no evidence that a person can get the virus from handling live or dead infected birds. However, avoid barehanded contact when handling dead animals, including dead birds. Ticks have not been implicated as vectors of West Nile-like virus.

Mild infections are common and include fever, headache, and body aches, often with skin rash and swollen lymph glands. More severe infection is marked by headache, high fever, neck stiffness, stupor, disorientation, coma, tremors, occasional convulsions, paralysis and, rarely death (noted especially in the elderly and very young). The incubation period of West Nile encephalitis is usually 3 to 12 days. There is no specific therapy or vaccine against West Nile encephalitis.

Precautions include where possible:

- Limit outdoor activities during peak mosquito times – at dusk and dawn
- Avoid standing water
- Wear long-sleeved shirts and long pants whenever you are outdoors.
- Apply insect repellent according to manufacturers' instruction to exposed skin. An effective repellent will contain 20% to 30% DEET (N,N-diethyl-meta-toluamide).
- Avoid products containing more than 30% DEET.

- Spray clothing with repellents containing permethrin or DEET, mosquitoes may bite through thin clothing.

6.3.3 Poisonous Plants

Various plants which can cause allergic reactions may be encountered during field work. These include poison ivy, poison oak, and poison sumac. Contact with these plants may occur when clearing vegetation for access to work areas, or as a result of movement through these plants. An irritating, allergic reaction can occur after direct contact with the plant or indirect contact through some piece of equipment or clothing article. Oils are transferred from the plant to exposed skin, clothing, or piece of equipment. The degree of the irritating, allergic reaction can vary significantly from one person to the next.

Protective measures to control and minimize the effects of this hazard may include, but not be limited to, the following:

- Identify plants for field personnel.
 - Poison Ivy - Characterized by climbing vines, three leaf configuration ovate to elliptical in shape, deep green leaves with a reddish tint, greenish flowers, and white berries.
 - Poison Sumac - Characterized as a tall bush of the sumac family bearing compound leaves (7-13 entire leaflets), branched from a central axis, drooping, with axillary clusters of white fruit: However, these white fruits and berries may exist only during pubescent stages.
 - Poison oak - Characterized as similar to poison ivy consisting of a shrub, stems erect, 0.3 to 2.0 meters tall, leaflets consist of broad thick lobes coarsely serrated configuration, denser at the base, less so than the top.
- Protective measures may include wearing disposable garments such as Tyvek when clearing brush. These may be carefully removed and disposed of along with any oils accumulated from the plants.
- Personal Hygiene - The oils obtained from the plants will only elicit an allergic response when the person's bare skin layer is contacted. This can be aggravated when skin pores are open (perspiring), or through breaks in the skin such as cuts, nicks, scratches, etc. This can also be accomplished when using excessively hot water for cleaning the skin, which also causes pores to open. Prior to break time, lunchtime, etc. personnel should wash with cool water and soap to remove as much of the oils as possible. In heavily vegetated areas of these plants, additional measures including barrier creams and blocks may be used to prevent the oils from accessing and penetrating the skin.

All of these plants present an airborne sensitization hazard when burned. This is not to occur as part of this scope of work and therefore will not be addressed.

7.0 XRF MONITORING

Based on available data and site history the primary contaminants of concern are lead, arsenic, and PAHs. Occupational exposures to the COCs are most likely to occur as a result of inhalation of metal-containing particulates. However, site operations are unlikely to generate airborne dusts in sufficient quantity to exceed the OELs. In the event that airborne dusts are observed, site workers will work from upwind locations away from visible dust clouds. If necessary, area wetting methods will be used to further suppress dusts.

Based on planned site activities, the greatest potential for exposure to lead is anticipated to be through skin contact with lead-contaminated soil or through incidental ingestion as a result of hand to mouth activities. As a result, air monitoring for airborne dusts is not necessary for this investigation. However, soil sampling using direct read instrumentation including a x-ray fluorescence (XRF) analyzer will be performed to determine the extent of the lead-contaminated soil for removal and for confirmatory sampling.

7.1 XRF ANALYZER

The instrument will be used to screen soils to determine concentrations of lead. The operation of the unit will be in accordance with training provided to field personnel and manufacturer's recommendations. The instrument will be calibrated using pre-prepared National Institute of Standards and Technology samples with low, moderate, and high concentrations of lead.

7.2 INSTRUMENT MAINTENANCE AND CALIBRATION

Hazard monitoring instruments will be maintained and pre-field calibrated by the Tetra Tech Equipment Manager or the vendor that is supplying the monitoring instrument. Operational checks and field calibration will be performed on instruments each day prior to their use. Field calibration will be performed on instruments according to manufacturer's recommendations. These operational checks and calibration efforts will be performed in a manner that complies with the employees health and safety training, the manufacturer's recommendations, and with the applicable manufacturer standard operating procedure (copies of which can be found in the Health & Safety Guidance Manual which will be maintained on site for reference). Calibration efforts must be documented. Figure 7-1 is provided for documenting these calibration efforts. This information may instead be recorded in a field operations logbook, provided that the information specified in Figure 7-1 is recorded. This required information includes the following:

- Date calibration was performed
- Individual calibrating the instrument

- Instrument name, model, and serial number
- Any relevant instrument settings and resultant readings (before and after) calibration
- Identification of the calibration standard (lot no., source concentration, supplier)
- Any relevant comments or remarks

7.3 DOCUMENTING INSTRUMENT READINGS

The SSO is responsible for ensuring that air monitoring instruments are used in accordance with the specifications of this HASP and with manufacturer's specifications/recommendations. In addition, the SSO is also responsible for ensuring that all instrument use is documented. This requirement can be satisfied either by recording instrument readings on pre-printed sampling log sheets or in a field log book. This includes the requirement for documenting instrument readings that indicate no elevated readings above noted daily background levels (i.e., no-exposure readings). At a minimum, the SSO must document the following information for each use of an air monitoring device:

- Date, time, and duration of the reading
- Site location where the reading was obtained
- Instrument used (e.g., XRF)
- Personnel present at the area where the reading was noted
- Other conditions that are considered relevant to the SSO (such as weather conditions, possible instrument interferences, etc.)

FIGURE 7-1

DOCUMENTATION OF FIELD CALIBRATION

SITE NAME: _____

PROJECT NO.: _____

Date of Calibration	Instrument Name and Model	Instrument I.D. Number	Person Performing Calibration	Instrument Settings		Instrument Readings		Calibration Standard (Lot Number)	Remarks/ Comments
				Pre-Calibration	Post-Calibration	Pre-Calibration	Post-Calibration		

8.0 TRAINING/MEDICAL SURVEILLANCE REQUIREMENTS

8.1 INTRODUCTORY/REFRESHER/SUPERVISORY TRAINING

This section specifies health and safety training and medical surveillance requirements for both Tetra Tech and subcontractor personnel participating in on site activities.

8.1.1 Requirements for Field Personnel

Tetra Tech and subcontractor personnel who will engage in field associated activities as described in this HASP must have:

- Completed 40 hours of introductory hazardous waste site training or equivalent work experience as defined in OSHA Standard 29 CFR 1910.120(e).
- Completed 8-Hour Refresher Training, if the identified persons had introductory training more than 12 months prior to site work.
- Completed 8-hour Supervisory training in accordance with 29 CFR 1910.120(e)(4), if their assigned function will involve the supervision of subordinate personnel.

Documentation of introductory training or equivalent work experience, supervisory, and refresher training as well as site-specific training will be maintained at the site. Copies of certificates or other official documentation will be used to fulfill this requirement.

8.2 SITE-SPECIFIC TRAINING

Tetra Tech will provide site-specific training to Tetra Tech employees and subcontractor personnel who will perform work on this project.

Figure 8-1 will be used to document the provision and content of the project-specific and associated training. Site personnel will be required to sign this form prior to commencement of site activities.

Tetra Tech will conduct a pre-activities training session prior to initiating site work. Additionally, a brief meeting will be held daily to discuss operations planned for that day. At the end of the workday, a short meeting may be held to discuss the operations completed and any problems encountered. This activity will be supported through the use of a Safe Work Permit System (See Section 9.0).

8.3 MEDICAL SURVEILLANCE

Tetra Tech and subcontractor personnel participating in project field activities will have had a physical examination. Physical examinations shall meet the minimum requirements of paragraph (f) of OSHA 29 CFR 1910.120. The physical examinations will be performed to ensure personnel are medically qualified to perform hazardous waste site work using respiratory protection. Additionally, the subcontractor will be responsible for determining medical surveillance requirements for their employees including applicability to the requirements of 29 Code of Federal Regulations (CFR) Part 1926.62 paragraph (j).

Documentation for medical clearances will be maintained at the job site and made available, as necessary. Subcontractor personnel may use an alternative documentation for this purpose. The "Subcontractor Medical Approval Form" can be used to satisfy this requirement, or a letter from an officer of the company. The letter should state that the persons listed in the letter participate in a medical surveillance program meeting the requirements contained in paragraph (f) of Title 29 of the CFR, Part 1910.120, as well as paragraph (j) of Part 1926.62. The letter should further state the following:

- The persons listed have had physical examinations under this program within the frequency as determined sufficient by their occupational health care provider
- Date of the exam
- The persons identified have been cleared, by a licensed physician, to perform hazardous waste site work and to wear positive- and negative- pressure respiratory protection.

A sample Subcontractor Medical Approval Form and form letter have been provided to eligible subcontractors in the Bid Specification package.

8.4 SUBCONTRACTOR EXCEPTION

If through the execution of their contract elements the subcontractor will not enter the exclusion zone and there is no potential for exposure to site contaminants, subcontractor personnel may be exempt from the training and medical surveillance requirements with the exception of Section 8.2. Examples of subcontractors who may qualify as exempt from training and medical surveillance requirements may include surveyors who perform surveying activities in site perimeter areas or areas where there is no potential for exposure to site contaminants and support or restoration services. **Use of this Subcontractor Exception is strictly limited to the authority of the Tetra Tech Health and Safety Manager.**

FIGURE 8-1

SITE-SPECIFIC TRAINING DOCUMENTATION

My signature below indicates that I am aware of the potential hazardous nature of performing site investigation activities at the Atwater Facility, and that I have received site-specific training that included the elements presented below:

- Names of designated personnel and alternates responsible for site safety and health
- Safety, health, and other hazards present on site
- Use of personal protective equipment
- Safe use of engineering controls and equipment
- Safe work practices to minimize risks from hazards
- Medical surveillance requirements
- Decontamination procedures
- Emergency response procedures (evacuation and assembly points
- Incipient response procedures
- Review of the contents of relevant Material Safety Data Sheets
- Review of the use of AHAs
- Spill containment program
- Stop work authority policy

My signature below indicates that I have been given the opportunity to ask questions and that my questions have been answered to my satisfaction. The dates of my training and medical surveillance indicated below are accurate.

[illegible]

9.0 SITE CONTROL

This section outlines the means that Tetra Tech will delineate work zones and use these work zones in conjunction with decontamination procedures to prevent the spread of contaminants into previously unaffected areas of the site. It is anticipated that a two-zone approach will be used during work at this site: Exclusion Zone, and Support Zone. It is also anticipated that this control measure will be used to control access to site work areas. Use of such controls will restrict the general public and protect individuals who are not cleared to enter the work areas.

9.1 EXCLUSION ZONE

The Exclusion Zone will be considered will be limited to those areas of the site where intrusive activities are being performed. Exclusion Zones will be delineated (e.g., barrier tape, cones and/or postings) to inform and direct facility personnel. Exclusion zones shall be structured using the following guidance:

- Soil removal activities – 35-feet
- Sampling and XRF activities – 15-feet
- Low pressure decontamination activities – 10-feet
- High Pressure washing and heavy equipment decontamination operations – 35-feet
- IDW – Authorized personnel only

Exclusion zones will be delineated using barrier tape, cones and/or drive poles, and postings to inform and direct facility site personnel and visitors, as necessary.

A pre-startup site visit will be conducted to identify proposed subsurface investigation locations, conduct utility clearances, and provide notices concerning scheduled activities.

9.2 SUPPORT ZONE

The Support Zone for this project will include a staging area where food and drink containers will be maintained. The Support Zone will be established next to the work site.

9.3 ACTIVITY HAZARD ANALYSIS

Work conducted in support of this project will be performed using AHAs to guide and direct field crews on a task by task basis. See Attachment III. It is the FOL/SSO's responsibility to review the AHAs with the task participants as part of a pre-task tail gate briefing session.

9.4 SITE VISITORS

Site visitors for the purpose of this document are identified as representing the following groups of individuals:

- Personnel invited to observe or participate in operations by Tetra Tech
- Regulatory personnel (EPA, OSHA, MDNRE, etc.)
- USCG Personnel
- Other authorized visitors

It is not anticipated that this operation will result in any site visitors. However, the following procedures will be followed if visitors are present at the site:

- Site visitors will report to the FOL, who will sign them in to the field logbook. Information to be recorded in the logbook will include the individual's name (proper identification required), who they represent, and purpose for the visit.
- To enter the site's operational Zones during planned activities, site visitors will be required to first go through site-specific training covering the topics stipulated in Section 8.2 of this document.

NOTE: Site visitors will be escorted while at the site.

Following this, the site visitor will be permitted to enter the site and applicable operational areas. Site visitors are required to observe the site restrictions in effect at the area of their visit. Visitors not meeting the requirements as stipulated in this plan for site clearance will not be permitted to enter the site operational zone during planned activities. Any incidence of unauthorized site visitation will cause the onsite activities to be terminated until that visitor can be removed. Removal of unauthorized visitors will be accomplished with support from the USCG Station Contact, if necessary.

9.5 SITE SECURITY

Site security will be accomplished using Tetra Tech field personnel. Tetra Tech will retain complete control over active operational areas. As this activity takes place at a facility open to public access, the first line of security will take place using exclusive zone barriers, site work permits, and any existing barriers at the sites to restrict the general public. The second line of security will take place at the work site referring interested parties to the site contact. The site contact will serve as a focal point for base personnel, interested parties, and serve as the final line of security and the primary enforcement contact.

9.6 SITE MAP

A site map with proposed operational areas has been generated and will be adjusted as site conditions change.

9.7 BUDDY SYSTEM

Personnel engaged in on site activities will practice the "buddy system" to make sure the safety of personnel involved in this operation.

9.8 MATERIAL SAFETY DATA SHEET (MSDS) REQUIREMENTS

Tetra Tech and subcontractor personnel will provide MSDSs for chemicals brought on site. The contents of these documents will be reviewed by the SSO with the user(s) of the chemical substances prior to any actual use or application of the substances on site. A chemical inventory of the chemicals used on site will be developed using the Health and Safety Guidance Manual. The MSDSs will then be maintained in a central location (i.e., temporary office) and will be available for anyone to review upon request.

9.9 COMMUNICATION

As personnel will be working in proximity to one another during field activities, a supported means of communication between field crew members will not be necessary. External communication will be accomplished by using cellular telephones or the Marine Radio on Channel 16. External communication will primarily be used for the purpose of resource and emergency resource communications. Cell phone service is available on the island and USCG Station Alpena monitors Channel 16 twenty four hours a day.

10.0 SPILL CONTAINMENT PROGRAM

10.1 SCOPE AND APPLICATION

It is not anticipated that bulk hazardous materials will be accumulated or handled as part of the scope of work. The only material that may be available on the island is a 5-gallon container of gasoline used to fuel the generator. Therefore it is also not anticipated that spillage of this material would constitute a danger to human health or the environment.

10.2 POTENTIAL SPILL AREAS

The area vulnerable to this hazard is the area used for central staging and decontamination.

10.3 LEAK AND SPILL DETECTION

Any identified leaks will be collected and contained using available materials such as soil or sand. This material will be containerized for disposal pending analyses.

10.4 PERSONNEL TRAINING AND SPILL PREVENTION

Personnel will be instructed on the procedures for spill prevention, containment, and collection of hazardous materials in the site-specific training. The FOL or SSO will serve as the Spill Response Coordinator for this operation should the need arise.

10.5 SPILL PREVENTION AND CONTAINMENT EQUIPMENT

Shovels, plastic garbage bags, labels will be available on the island for the purpose of supporting this Spill Prevention/Containment Program.

10.6 SPILL CONTROL PLAN

If the gasoline is spilled, the field crew will immediately handle the situation. They will use the available PPE brought to the island to conduct sampling. They will take immediate actions to stop the leak or spill by plugging or patching the drum/container or raising the leak to the highest point. They will control the spread by covering the spill completely with soil. Once contained they will transfer the material to a plastic bag and label it appropriately. If necessary they will place the contaminated soil in a safe location and determine shipment or disposal options.

11.0 CONFINED-SPACE ENTRY

It is not anticipated, under the proposed scope of work, that confined space and permit-required confined space activities will be conducted. **Therefore, personnel under the provisions of this HASP are not allowed, under any circumstances, to enter any confined spaces.**

A confined space is a space that:

- Is large enough and so configured that an employee can bodily enter and perform assigned work.
- Has limited or restricted means for entry or exit (for example, tanks, vessels, silos, storage bins, hoppers, vaults, and pits are spaces that may have limited means of entry).
- Is not designed for continuous employee occupancy.

A Permit-Required Confined Space is a confined space that has one or more of the following characteristics:

- Contains or has a potential to contain a hazardous atmosphere.
- Contains a material that has the potential to engulf an entrant.
- Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or by a floor that slopes downward and tapers to a smaller cross-section.
- Contains any other recognized, serious, safety or health hazard.

For further information on confined space, consult the Health and Safety Guidance Manual or call the PHSO. If confined space operations are to be performed as part of the scope of work, detailed procedures and training requirements will have to be addressed.

12.0 MATERIALS AND DOCUMENTATION

The Tetra Tech FOL shall make sure that the following materials/documents are taken to the project site and used when required:

- A complete copy of this HASP
- Incident Reports
- Medical Data Sheets
- Material Safety Data Sheets for the chemicals brought on site, including decon solution, fuels, sample preservations, calibration gases, etc.
- A full size OSHA Job Safety and Health Poster and Lead Warning Sign (Attachment VI)
- Training/Medical Surveillance Documentation Form (blank)
- Emergency Reference Form (Section 2.0)

12.1 MATERIALS TO BE POSTED OR MAINTAINED AT THE SITE

The following documentation is to be posted or maintained at the site for quick reference purposes. In situations where posting specified documents is not feasible (such as no office trailer) these documents should be separated and immediately accessible.

Chemical Inventory Listing (maintained) - This list represents the chemicals brought on site, including decontamination solutions, sample preservations, fuel, etc. This list should be posted in a central area.

Material Safety Data Sheets (MSDS) (maintained) - The MSDSs should also be in a central area accessible to the site personnel. These documents should match the listings on the chemical inventory list for substances employed on site. It is acceptable to have these documents within a central folder and the chemical inventory as the table of contents.

The OSHA Job Safety & Health Protection Poster (posted) - this poster, as directed by 29 CFR 1903.2 (a)(1), should be conspicuously posted in places where notices to employees are normally posted. Each FOL shall make sure that this poster is not defaced, altered, or covered by other material.

Site Clearance Posting (maintained) - This list is found within the training section of the HASP (see Figure 8-1). This list identifies the site personnel, dates of training (including site-specific training), and medical surveillance. The list indicates not only clearance but also status. If personnel do not meet these requirements, they do not enter the site while site personnel are engaged in activities.

Emergency Phone Numbers and Directions to the Hospital(s) (posted) - This list of numbers and directions will be maintained at the phone communications points and in each site vehicle.

Medical Data Sheets/Cards (maintained) - Medical Data Sheets will be filled out by on site personnel and filed in a central location. The Medical Data Sheet will accompany any injury or illness requiring medical attention to the medical facility.

Hearing Conservation Standard (29 CFR 1910.95) (posted) - This standard will be posted anytime hearing protection or other noise abatement procedures are employed.

Monitoring Results - The results obtained from real-time monitoring and air sampling will be posted and communicated to affected personnel.

The purpose, as stated above, is to allow site personnel quick access to this information. Variations concerning location and methods of presentation are acceptable, providing the objection is accomplished.

13.0 GLOSSARY

ALARA	As Low As Reasonably Achievable
APR	Air Purifying Respirator
AST	Above-ground Storage Tank
bgs	Below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CIH	Certified Industrial Hygienist
COC	Contaminants of Concern
CRZ	Contamination Reduction Zone
CSP	Certified Safety Professional
dba	decibel on A-weighted scale
eV	electron Volts
EPA	Environmental Protection Agency
FOL	Field Operations Leader
HASP	Health and Safety Plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
HSM	Health and Safety Manager
IDLH	Immediate Dangerous to Life or Health
mR/hr	milli rem per hour
MSDS	Material Safety Data Sheets
NIOSH	National Institute for Occupational Safety and Health
OSHA	Occupational Safety and Health Administration (U.S. Department of Labor)
PEL	Permissible Exposure Limit
PHSO	Project Health and Safety Officer
SOPs	Standard Operating Procedures
SSO	Site Safety Officer
TBD	To be determined
PM	Project Manager
TWA	Time-Weighted Average
USCG	United States Coast Guard
WP	Work Plan
XRF	X-Ray Fluorescence Analyzer

ATTACHMENT I

INCIDENT REPORT FORM



Report Date	Report Prepared By	Incident Report Number
INSTRUCTIONS: All incidents (including those involving subcontractors under direct supervision of Tetra Tech personnel) must be documented on the IR Form. Complete any additional parts to this form as indicated below for the type of incident selected.		
TYPE OF INCIDENT (Check all that apply) Near Miss (No losses, but could have resulted in injury, illness, or damage) Injury or Illness Property or Equipment Damage, Fire, Spill or Release Motor Vehicle		Additional Form(s) Required for this type of incident <input type="checkbox"/> Complete IR Form Only <input type="checkbox"/> Complete Form IR-A; Injury or Illness <input type="checkbox"/> Complete Form IR-B; Damage, Fire, Spill or Release <input type="checkbox"/> Complete Form IR-C; Motor Vehicle
INFORMATION ABOUT THE INCIDENT		
Description of Incident 		
Date of Incident	Time of Incident _____ AM <input type="checkbox"/> PM <input type="checkbox"/> OR Cannot be determined <input type="checkbox"/>	
Weather conditions at the time of the incident	Was there adequate lighting? _____ Yes <input type="checkbox"/> No <input type="checkbox"/>	
Location of Incident _____ Was location of incident within the employer's work environment? Yes <input type="checkbox"/> No <input type="checkbox"/>		
Street Address	City, State, Zip Code and Country	
Project Name	Client:	
Tt Supervisor or Project Manager	Was supervisor on the scene? Yes <input type="checkbox"/> No <input type="checkbox"/>	
WITNESS INFORMATION (attach additional sheets if necessary)		
Name	Company	
Street Address	City, State and Zip Code	
Telephone Number(s)		

CORRECTIVE ACTIONS				
Corrective action(s) immediately taken by unit reporting the incident:				
Corrective action(s) still to be taken (by whom and when):				
ROOT CAUSE ANALYSIS LEVEL REQUIRED				
Root Cause Analysis Level Required: Level - 1 <input type="checkbox"/> Level - 2 <input type="checkbox"/> None <input type="checkbox"/>				
Root Cause Analysis Level Definitions				
Level - 1	<p>Definition: A Level 1 RCA is conducted by an individual(s) with experience or training in root cause analysis techniques and will conduct or direct documentation reviews, site investigation, witness and affected employee interviews, and identify corrective actions. Activating a Level 1 RCA and identifying RCA team members will be at the discretion of the Corporate Administration office.</p> <p>The following events may trigger a Level 1 RCA:</p> <ul style="list-style-type: none"> Work related fatality Hospitalization of one or more employee where injuries result in total or partial permanent disability Property damage in excess of \$75,000 When requested by senior management 			
Level - 2	<p>Definition: A Level 2 RCA is self performed within the operating unit by supervisory personnel with assistance of the operating unit HSR. Level 2 RCA will utilize the 5 Why RCA methodology and document the findings on the tools provided.</p> <p>The following events will require a Level 2 RCA:</p> <ul style="list-style-type: none"> OSHA recordable lost time incident Near miss incident that could have triggered a Level 1 RCA When requested by senior management 			
Complete the Root Cause Analysis Worksheet and Corrective Action form. Identify a corrective action(s) for each root cause identified within each area of inquiry.				
NOTIFICATIONS				
Title	Printed Name	Signature	Telephone Number	Date
Project Manager or Supervisor				
Site Safety Coordinator or Office H&S Representative				
Operating Unit H&S Representative				
Other: _____				

The signatures provided above indicate that appropriate personnel have been notified of the incident.



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INCIDENT FORM IR-A

INSTRUCTIONS:

Complete all sections below for incidents involving injury or illness.

Do NOT leave any blanks.

Attach this form to the IR FORM completed for this incident.

Incident Report Number: (From the IR Form)

EMPLOYEE INFORMATION

Company Affiliation

Tetra Tech Employee? ☐

TetraTech subcontractor employee (directly supervised by Tt personnel)? ☐

Full Name

Company (if not Tt employee)

Street Address, City, State and Zip Code

Address Type

Home address (for Tt employees) ☐

Business address (for subcontractors) ☐

Telephone Numbers

Work: _____

Home: _____

Cell: _____

Occupation (regular job title)

Department

Was the individual performing regular job duties?

Yes ☐ No ☐

Time individual began work

_____ AM ☐ PM ☐ OR Cannot be determined ☐

Safety equipment

Provided? Yes ☐ No ☐

Used? Yes ☐ No ☐ If no, explain why

Type(s) provided: ☐ Hard hat ☐ Protective clothing
☐ Gloves ☐ High visibility vest
☐ Eye protection ☐ Fall protection
☐ Safety shoes ☐ Machine guarding
☐ Respirator ☐ Other (list)

NOTIFICATIONS

Name of Tt employee to whom the injury or illness was first reported

Was H&S notified within one hour of injury or illness?

Yes ☐ No ☐

Date of report

H&S Personnel Notified

Time of report

Time of Report

If subcontractor injury, did subcontractor's firm perform their own incident investigation?

Yes ☐ No ☐ If yes, request a copy of their completed investigation form/report and attach it to this report.



INJURY / ILLNESS DETAILS

What was the individual doing just before the incident occurred? Describe the activity as well as the tools, equipment, or material the individual was using. Be specific. Examples: "Climbing a ladder while carrying roofing materials"; "Spraying chlorine from a hand sprayer"; "Daily computer key-entry"

What Happened? Describe how the injury occurred. Examples: "When ladder slipped on wet floor and worker fell 20 feet"; "Worker was sprayed with chlorine when gasket broke during replacement"; "Worker developed soreness in wrist over time"

Describe the object or substance that directly harmed the individual: Examples: "Concrete floor"; "Chlorine"; "Radial Arm Saw". If this question does not apply to the incident, write "Not Applicable".

MEDICAL CARE PROVIDED

Was first aid provided at the site: Yes ☐ No ☐ If yes, describe the type of first aid administered and by whom?

Was treatment provided away from the site: Yes ☐ No ☐ If yes, provide the information below.

Name of physician or health care professional	Facility Name
<hr/>	<hr/>
Street Address, City State and Zip Code	Type of Care?
<hr/>	Was individual treated in emergency room? Yes <input type="checkbox"/> No <input type="checkbox"/>
<hr/>	Was individual hospitalized overnight as an in-patient? Yes <input type="checkbox"/> No <input type="checkbox"/>
Telephone Number	Did the individual die? Yes <input type="checkbox"/> No <input type="checkbox"/> If yes, date: <hr/>
<hr/>	Will a worker's compensation claim be filed? Yes <input type="checkbox"/> No <input type="checkbox"/>

NOTE: Attach any police reports or related diagrams to this report.

SIGNATURES

I have reviewed this report and agree that all the supplied information is accurate

Affected individual (print)	Affected individual (signature)	Telephone Number	Date
<hr/>	<hr/>	<hr/>	<hr/>

This form contains information relating to employee health and must be used in a manner that protects the confidentiality of the employee to the extent possible while the information is being used for occupational safety and health purposes.

**INSTRUCTIONS:**

Complete all sections below for incidents involving property/equipment damage, fire, spill or release.

Do NOT leave any blanks.

Attach this form to the IR FORM completed for this incident.

Incident Report Number: (From the IR Form)

TYPE OF INCIDENT (Check all that apply)Property Damage ☐Equipment Damage ☐Fire or Explosion ☐Spill or Release ☐**INCIDENT DETAILS****Results of Incident:** Fully describe damages, losses, etc.

Response Actions Taken:

Responding Agency(s) (i.e. police, fire department, etc.)

Agency(s) Contact Name(s)

DAMAGED ITEMS (List all damaged items, extent of damage and estimated repair cost)

Item:	Extent of damage:	Estimated repair cost

SPILLS / RELEASES (Provide information for spilled/released materials)

Substance	Estimated quantity and duration	Specify Reportable Quantity (RQ)
		_____ Exceeded? Yes <input type="checkbox"/> No <input type="checkbox"/> NA <input type="checkbox"/>

FIRES / EXPLOSIONS (Provide information related to fires/explosions)Fire fighting equipment used? Yes ☐ No ☐ If yes, type of equipment: _____**NOTIFICATIONS**

Required notifications	Name of person notified	By whom	Date / Time
Client: _____ Yes <input type="checkbox"/> No <input type="checkbox"/>			
Agency: _____ Yes <input type="checkbox"/> No <input type="checkbox"/>			
Other: _____ Yes <input type="checkbox"/> No <input type="checkbox"/>			

Who is responsible for reporting incident to outside agency(s)? Tt ☐ Client ☐ Other ☐ Name: _____Was an additional written report on this incident generated? Yes ☐ No ☐ If yes, place in project file.

**INSTRUCTIONS:**

Complete all sections below for incidents involving motor vehicle accidents. Do NOT leave any blanks.

Attach this form to the IR FORM completed for this incident.

Incident Report Number: (From the IR Form)					
INCIDENT DETAILS					
Name of road, street, highway or location where accident occurred				Name of intersecting road, street or highway if applicable	
County		City		State	
Did police respond to the accident?			Did ambulance respond to the accident?		
Yes <input type="checkbox"/> No <input type="checkbox"/>			Yes <input type="checkbox"/> No <input type="checkbox"/>		
Name and location of responding police department			Ambulance company name and location		
Officer's name/badge #					
Did police complete an incident report? Yes <input type="checkbox"/> No <input type="checkbox"/> If yes, police report number: _____ Request a copy of completed investigation report and attach to this form.					
VEHICLE INFORMATION					
How many vehicles were involved in the accident? _____ (Attach additional sheets as applicable for accidents involving more than 2 vehicles.)					
Vehicle Number 1 – Tetra Tech Vehicle			Vehicle Number 2 – Other Vehicle		
Vehicle Owner / Contact Information			Vehicle Owner / Contact Information		
Color			Color		
Make			Make		
Model			Model		
Year			Year		
License Plate #			License Plate #		
Identification #			Identification #		
Describe damage to vehicle number 1			Describe damage to vehicle number 2		
Insurance Company Name and Address			Insurance Company Name and Address		
Agent Name			Agent Name		
Agent Phone No.			Agent Phone No.		
Policy Number			Policy Number		



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DRIVER INFORMATION							
Vehicle Number 1 – Tetra Tech Vehicle				Vehicle Number 2 – Other Vehicle			
Driver's Name				Driver's Name			
Driver's Address				Driver's Address			
Phone Number				Phone Number			
Date of Birth				Date of Birth			
Driver's License #				Driver's License #			
Licensing State				Licensing State			
Gender		Male <input type="checkbox"/> Female <input type="checkbox"/>		Gender		Male <input type="checkbox"/> Female <input type="checkbox"/>	
Was traffic citation issued to Tetra Tech driver? Yes <input type="checkbox"/> No <input type="checkbox"/>				Was traffic citation issued to other vehicle driver? Yes <input type="checkbox"/> No <input type="checkbox"/>			
Citation #				Citation #			
Citation Description				Citation Description			
PASSENGERS IN VEHICLES (NON-INJURED)							
<p>List all non-injured passengers (excluding driver) in each vehicle. Driver information is captured in the preceding section. Information related to persons injured in the accident (non-Tt employees) is captured in the section below on this form. Injured Tt employee information is captured on FORM IR-A</p>							
Vehicle Number 1 – Tetra Tech Vehicle				Vehicle Number 2 – Other Vehicle			
How many passengers (excluding driver) in the vehicle? ____				How many passengers (excluding driver) in the vehicle? ____			
Non-Injured Passenger Name and Address				Non-Injured Passenger Name and Address			
Non-Injured Passenger Name and Address				Non-Injured Passenger Name and Address			
Non-Injured Passenger Name and Address				Non-Injured Passenger Name and Address			
INJURIES TO NON-TETRATECH EMPLOYEES							
Name of injured person 1				Address of injured person 1			
Age	Gender	Car No.	Location in Car	Seat Belt Used?	Ejected from car?	Injury or Fatality?	
	Male <input type="checkbox"/> Female <input type="checkbox"/>			Yes <input type="checkbox"/> No <input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>	Injured <input type="checkbox"/> Died <input type="checkbox"/>	
Name of injured person 2				Address of injured person 2			
Age	Gender	Car No.	Location in Car	Seat Belt Used?	Ejected from car?	Injury or Fatality?	
	Male <input type="checkbox"/> Female <input type="checkbox"/>			Yes <input type="checkbox"/> No <input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>	Injured <input type="checkbox"/> Died <input type="checkbox"/>	
OTHER PROPERTY DAMAGE							
Describe damage to property other than motor vehicles							
Property Owner's Name				Property Owner's Address			



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COMPLETE AND SUBMIT DIAGRAM DEPICTING WHAT HAPPENED

ATTACHMENT II

MEDICAL DATA SHEET

MEDICAL DATA SHEET

This Medical Data Sheet must be completed by on-site personnel and kept in the command post during the conduct of site operations. This data sheet will accompany any personnel when medical assistance is needed or if transport to hospital facilities is required.

Project _____
Name _____ Home Telephone _____
Address _____
Age _____ Height _____ Weight _____

Person to notify in the event of an emergency: Name: _____
Phone: _____

Drug or other Allergies: _____

Particular Sensitivities: _____

Do You Wear Contacts? _____

What medications are you presently using? _____

Name, Address, and Phone Number of personal physician: _____

Note: Health Insurance Portability and Accountability Act (HIPAA) Requirements

HIPAA took effect April 14, 2003. Loosely interpreted, HIPAA regulates the disclosure of Protected Health Information (PHI) by the entity collecting that information. PHI is any information about health status (such as that you may report on this Medical Data Sheet), provision of health care, or other information. HIPAA also requires Tetra Tech to ensure the confidentiality of PHI. This Act can affect the ability of the Medical Data Sheet to contain and convey information you would want a physician to know if you were incapacitated. So before you complete the Medical Data Sheet understand that this form will not be maintained in a secure location. It will be maintained in a file box or binder accessible to other members of the field crew so that they can accompany an injured party to the hospital.

DO NOT include information that you do not wish others to know, only information that may be pertinent in an emergency situation or treatment.

Name (Print clearly) _____ Signature _____ Date _____

ATTACHMENT III

ACTIVITY HAZARD ANALYSIS



ACTIVITY HAZARD ANALYSIS (AHA)

Site Name: Atwater Facility

Task: Site Mobilization/Demobilization and Land Survey

Prepared by	J Carothers, PhD	Date	11/11	FOL	
Reviewed by	C. Snyder	Date	11/11	SSO	
JOB STEPS		HAZARDS		CONTROLS	
Mobilization / Demobilization <ul style="list-style-type: none"> Assembling equipment and supplies Performing initial/exit inspections of the intended work areas Arranging for utilities, site access, notifying appropriate client contacts Performing equipment inspections of vehicles and equipment arriving/preparing to depart the site Collecting and confirming applicable worker training and medical compliance documentation Land surveying 		1. Skid Steer Loader 2. Minor cuts, abrasions or contusions 3. Heavy lifting (muscle strains and pulls) 4. Vehicular traffic when moving large equipment to the support area 5. Intermittent high noise levels 6. Equipment moving parts		1. Conduct initial site acceptance inspection. This must be completed prior to performing any work at this site. Use the equipment inspection checklist for in Attachment IV. 2. Wear cut-resistant gloves when handling items with sharp or rough edges. 3. Practice safe lifting techniques (use mechanical lifting devices such as a dolly whenever possible, ensure clear path of travel, good grasp on object, perform "test lift" to gauge ability to safely make the lift, lift with legs not back, obtain help when needed to lift large, bulky, or heavy items). 4. Designate vehicle and equipment staging areas. Inform site personnel of heavy equipment areas and of their responsibility to stay clear of moving vehicles. In high traffic areas, wear high-visibility vests. 5. Operators/nearby personnel are to wear hearing protection if noise levels are such that they must raise their voice in order to communicate with someone who is within arm's reach (approx. 2') of them. FOL/SSO is responsible for determining and designating when hearing protection is required. Hearing protection is to consist of either ear muffs or plugs that have a noise reduction rating (NRR) of at least 25 dB. 6. Ensure that workers are trained and competent to perform their assigned task with the equipment. Ensure that back-up alarms are functional on equipment. The equipment operators and on-site Supervisors responsible for the equipment are to ensure that the equipment has been inspected and accepted for onsite use. Check emergency stop controls.	

ACTIVITY HAZARD ANALYSIS
Site Mobilization/Demobilization
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JOB STEPS	HAZARDS	CONTROLS
	7. Slips, trips and falls	7. Maintain good housekeeping in IDW storage areas, keeping it clear of loose debris and other potential tripping hazards. Wear appropriate foot protection to prevent slips and trips. Use caution when working on uneven and wet ground surfaces.
EQUIPMENT TO BE USED	INSPECTION REQUIREMENTS	TRAINING REQUIREMENTS
Hand tools (dollies, hand carts, hand knives, etc.)	Visual inspection prior to use by user.	Review of AHA during pre-task tailgate safety briefing with all intended task participants.
Personal Protective Equipment: <u>Minimum</u>: Safety toe boots, safety glasses. <u>Optional items</u>: Hardhat, hearing protection. HTRW: None	Initial PPE inspection performed by FOL/SSO. Ongoing (prior to each use) inspections responsibilities of PPE users.	PPE training in proper use, care, storage, and limitations. It is anticipated that this has been covered in employees' 40 hour HAZWOPER training, which is to be verified by the FOL/SSO through initial training documentation and review prior to permitting personnel to participate in any onsite activities, and will be confirmed by visual observations of worker activities.

I have read and understand this AHA:

Name (Printed)	Signature	Date



ACTIVITY HAZARD ANALYSIS (AHA)

Site Name: Atwater Facility

Task: Soil Excavation and Restoration, and Confirmation Sampling, and XRF analysis

Prepared by	J Carothers, PhD	Date	11/11	FOL	
Reviewed by	C. Snyder	Date	11/11	SSO	

Task Steps	Hazards	Critical Safety Procedures and Controls
Oversight of Excavation activities	1. Lifting (strain/muscle pulls)	1. Lifting Hazards - Use machinery or multiple personnel for heavy lifts. 2. Use proper lifting techniques. See Section 4.0 of the HSGM.
	2. Slips, trips, and falls	1. Slips, Trips, and Falls - Preview work locations for unstable/uneven terrain. 2. Cover, guard and barricade the open pits, ditches, and floor opening as necessary. 3. Ruts, roots, tools, and other tripping hazards should be eliminated approaching points of operation to minimize trips and falls when approaching operating equipment. This is a prevalent hazard as remnants of concrete piping stands are along identified travel paths. 4. Maintain a clutter free work area. 5. As part of site control efforts construct fences or other means of demarcation (i.e. signs and postings) to control and isolate traffic in the work area. Means of demarcation shall also be constructed isolating resource and/or staging areas. 6. Workers will not enter an excavation deeper than 4 feet.
	3. Overhead and foot hazards	1. Hard hats and safety toe foot wear meeting ANSI specifications, safety glasses and high visibility vests will be worn as minimum equipment for on-site activities within the operational zones.
	4. Heat/Cold Stress	1. Follow the provisions as specified in Section 4.0 of the Tetra Tech Health and Safety Guidance Manual regarding the identification and evaluation of heat/cold stress related conditions.
	5. Inclement weather	1. Wear appropriate clothing for weather conditions. 2. Provide acceptable shelter and replacement liquids for field crews as relief from excessive ambient temperatures. 3. If someone is suffering from a heat/cold related disorder, it may be necessary to conduct heat/cold stress monitoring as prescribed in Section 4.0 of the HSGM. 4. Electrical storms/high winds - Suspend or terminate operations until directed otherwise by SSO. 5. Follow the 30/30 Rule. <i>If there is less than 30 seconds between thunder and</i>

ACTIVITY HAZARD ANALYSIS
Soil excavation, restoration and sampling
Page 2 of 5

Task Steps	Hazards	Critical Safety Procedures and Controls
		<i>lightning go inside and stay there for at least 30 minutes until after the last thunder.</i>
Oversight of Skid-steer loader operation	1. Operation	<p>1. Make sure that site workers understand the manufacturers' warnings and instructions before they operate skid-steer loaders. The following safe work practices will minimize hazardous situations associated with operating and maintaining skid-steer loaders:</p> <ul style="list-style-type: none"> • Operate the loader from the operator's compartment—never from the outside. • Stay seated when operating the loader controls. • Work with the seat belt fastened and the restraint bar in place. • Keep arms, legs, and head inside the cab while operating the loader. • When possible, plan to load, unload, and turn on level ground. • For maximum stability, travel and turn with the bucket in the lowest position possible. • Never exceed the manufacturer's recommended load capacity for the machine. • Operate on stable surfaces only. <ul style="list-style-type: none"> – Avoid traveling across slopes – Travel straight up or down with the heavy end of the machine pointed uphill. • Always face the direction of travel. • Keep bystanders away from the work area. • NEVER modify or bypass safety devices.
	2. Entering and exiting	<p>1. Enter only when the bucket or other attachment is flat on the ground—or when the lift-arm supports are in place. Use supports supplied or recommended by the manufacturer.</p> <ul style="list-style-type: none"> • When entering the loader, face the seat and keep a three-point contact with handholds and steps. • Never use foot or hand controls for steps or handholds. • Keep all walking and working surfaces clean and clear of debris. • Before leaving the operator's seat, <ul style="list-style-type: none"> – Lower the bucket or other attachment flat to the ground – Set the parking brake – Turn off the engine <p>2. If you are unable to exit through the front of the machine, use the emergency exit through the roof or across the back.</p>

ACTIVITY HAZARD ANALYSIS
Soil excavation, restoration and sampling
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Task Steps	Hazards	Critical Safety Procedures and Controls
	4. High noise levels	<ol style="list-style-type: none"> Operators/nearby personnel are to wear hearing protection if noise levels are such that they must raise their voice in order to communicate with someone who is within arm's reach (approx. 2') of them. SSO responsible for determining and designating when hearing protection is required. Hearing protection is to consist of either ear muffs or ear plugs that have an NRR of at least 25 dB. It is the responsibility of the SSO to implement the Site-Specific Hearing Conservation Program (See Section 6.0 of the HSGM) as well as posting 29 CFR 1910.95 Occupational Noise Exposure to ensure employee access..
	5. Equipment moving parts/Struck by	<ol style="list-style-type: none"> Ensure that workers are thoroughly trained and competent to perform their assigned task with the equipment used in the investigation. Ensure that back-up alarms are functional on equipment. The equipment operators and on-site Supervisors responsible for the equipment are to ensure that the equipment inspection forms (Appendix II) have been reviewed and completed, and that the moving parts are guarded if such parts are exposed. Check/test the emergency stop controls. Use escort vehicles with flashing lights to warn and control local traffic when moving large equipment to support area. Ground personnel will not place themselves between trucks or operating equipment. Always approach from the front within the operators view. Get the Operator's attention and have him lower the boom and bucket and disengaged the controls signaling. The Operator should signal when it is safe to approach. Traffic to the extent possible will be routed in a singular direction minimizing backing. Barricades will be placed to prevent the trucks from nearing the excavation to closely. Use the $\frac{3}{4}$ of the excavation depth as a distance unless sloped.
Refueling	1. Fire	<ol style="list-style-type: none"> Service or refueling areas will have at least one 20 BC fire extinguisher within 25-75 feet of dispenser. Equipment will be "Off" while refueling. Training will be provided to employees handling flammable and combustible liquids
XRF	1. Radiation exposure	<ol style="list-style-type: none"> The area where the device will be used will be identified using signs warning persons entering the area of the activities being conducted. The operator will ensure persons not critical to the operation are not in the area demarcated for this purpose. The operator will ensure good general housekeeping is practiced in the analytical area to control potential contamination within a confined space.

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Soil excavation, restoration and sampling
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Task Steps	Hazards	Critical Safety Procedures and Controls
		<ol style="list-style-type: none"> 4. The operator will practice good work hygiene practices to minimize potential introduction of residual contamination into the body through hand to mouth contact. 5. Radiation levels reported during testing are <0.1 mR/hr on all surfaces of the analyzer except at or near the exit port for the radiation. This means that if an operator follows standard operating procedures, they will not obtain any detectable radiation dose above naturally occurring background radiation, on their hand while holding the analyzer, or on any area of their body. 6. Plug the battery charger into a grounded electrical outlet that is easily accessible at all times. 7. When unplugging the cord from the electrical outlet, grasp and pull the cord by the plug. 8. Handle battery packs properly; do not : disassemble, crush, puncture, short external contacts, dispose of in fire or water, or expose a battery pack to temperatures higher than 60°C (140°F). 9. Do not attempt to open or service a battery pack. Improper handling or charging may cause the battery to explode. 10. Keep all safe guards and warning labels in place 11. Never point the instrument at another person. 12. Never hold a sample in your hand and test that part of the sample. 13. Establish Controlled Areas prior to use. 14. The location of storage and use should be of restricted access to limit potential exposure to possible ionizing radiation. 15. In use, the target should not be handled and the area at least three paces beyond the target should be unoccupied. 16. The instrument should be stored, in a locked case, or locked cabinets when not in use. 17. Operators should minimize the time around the energized instrument, maximize the distance from the instrument window during shots, and shoot into high density materials whenever possible. 18. All reasonable measures, including labeling, operator training and certification, and the concepts of time, distance, & shielding, should be implemented to limit radiation exposure to as low as reasonably achievable (ALARA).
EQUIPMENT TO BE USED	INSPECTION REQUIREMENTS	TRAINING REQUIREMENTS
Skid steer loader, soil sampling equipment and	SSO to pre-inspect equipment	The personnel participating in this activity must be current with HAZWOPER training requirements.

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Soil excavation, restoration and sampling
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EQUIPMENT TO BE USED	INSPECTION REQUIREMENTS	TRAINING REQUIREMENTS
Innov-X XRF analyzer		<p>Heavy equipment operators must demonstrate experience in proper vehicle/equipment operations. Over the road heavy equipment operators must possess appropriate DOT licenses.</p> <p>XRF Operators must be thoroughly familiar with the operation of the instrument. Read the manufactures manual and follow the safety precautions listed above.</p>
<p>Personal Protective Equipment: <u>Minimum</u>: Safety toe boots, safety glasses, nitrile surgical style gloves <u>Optional items</u>: Tyvek coveralls if possibility of soiling clothing HTRW: Lead</p>	Initial PPE inspection performed by SSO. Ongoing (prior to each use) inspections responsibilities of PPE users.	PPE training in proper use, care, storage, and limitations. It is anticipated that this has been covered in employees 40 hour HAZWOPER training, which is to be verified by the SSO through initial training documentation and review prior to permitting personnel to participate in site activities, and will be confirmed by visual observations of worker activities

I have read and understand this AHA:

Name (Printed)	Signature	Date



ACTIVITY HAZARD ANALYSIS (AHA)

Site Name: Atwater Facility

Task: Soil removal

Prepared by	J Carothers, PhD	Date	11/11	FOL	
Reviewed by	C. Snyder	Date	11/11	SSO	

JOB STEPS	HAZARDS	CONTROLS
Excavate soil Remove and containerize soil in super sacks Backfill area to grade, seed and restore original conditions	<ol style="list-style-type: none"> Minor cuts, abrasions or contusions Slips, Trips, Falls Muscle strains, tendon or ligament sprains, back or other soft-tissue injuries Bruises, abrasions, cuts, foot or eye injuries UV Radiation Heavy Equipment Operation Physical Strain 	<ol style="list-style-type: none"> When handling equipment and tools wear cut-resistant gloves when handling items with sharp or rough edges. Clear intended work areas and walking paths of roots, weeds, limbs and other ground hazards. Practice good housekeeping to keep the site clear of obstructions, materials, equipment and other tripping hazards. Ensure that work boots have adequately-aggressive sole design. Use caution when working on uneven and wet ground. Operating a hand auger can be physically demanding depending on the conditions of the soil, the auger tools, and the physical capabilities of the operator. Only personnel who are confident in their physical ability should perform this activity. Avoid injury by stopping if strong resistance is encountered (such as if impassable rocky conditions are encountered). Secure assistance when needed. Wear appropriate PPE (work gloves, safety toe shoes, and safety impact eye protection). Site personnel will be cautioned about the possibility of sunburns and will be use sunscreen with a minimum SPF 30 on exposed skin. Heavy equipment operators will be trained on the use, inspection and maintenance of the heavy equipment they use, and all site personnel will be briefed regarding safe operation near heavy equipment. Wear a high visibility safety vest, coat or shirt when working within 50 feet of heavy equipment or in other high traffic areas. Personnel will be cautioned about physical strain associated with strenuous activities that may be conducted at the site. Personnel will use caution to not over exert themselves or overstrain muscles and joints. Proper lifting techniques will be emphasized.
	8. COC contaminated dusts	<ol style="list-style-type: none"> Generation of dusts should be minimized. If airborne dusts are observed use area-wetting methods. Site contaminants may adhere to or be part of airborne dusts or particulates. All though unlikely to be present, the generation of dusts should be minimized to avoid inhalation of contaminated dusts or particulates.

ACTIVITY HAZARD ANALYSIS

Soil removal

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JOB STEPS	HAZARDS	CONTROLS
	9. Noise in excess of 85 dBA	<ol style="list-style-type: none"> Hearing protection will be used during the subsurface activities using the excavator when noise levels are > 85 dBA (during operation). Boundaries will be established to limit noise hazard. Excessive noise levels are being approached when you have to raise your voice to talk to someone within 2 feet of your location.
	10. Inclement weather	<ol style="list-style-type: none"> Wear appropriate clothing for weather conditions. <ul style="list-style-type: none"> Provide acceptable shelter and replacement liquids for field crews as relief from excessive ambient temperatures. If someone is suffering from a heat/cold related disorder, it may be necessary to conduct heat/cold stress monitoring as prescribed in Section 4.0 of the HSGM. Electrical storms/high winds - Suspend or terminate operations until directed otherwise by SSO. Follow the 30/30 Rule. <i>If there is less than 30 seconds between thunder and lightning go inside and stay there for at least 30 minutes until after the last thunder.</i> <p>Follow the provisions as specified in Section 4.0 of the Tetra Tech Health and Safety Guidance Manual regarding the identification and evaluation of heat/cold stress related conditions.</p>
EQUIPMENT	INSPECTION	TRAINING
Skid Steer Loader, hand tools and equipment	Visual inspection prior to use by user.	Training/experience in proper sample collection, handling and chain of custody requirements.
<p>Personal Protective Equipment: Minimum: cotton or leather work gloves, safety toe boots, safety glasses Optional items: Hardhat, hearing protection. HTRW: Lead, Area wetting</p>	Initial PPE inspection performed by FOL/SSO. Ongoing (prior to each use) inspections responsibilities of PPE users.	<p>OSHA 40 Hazardous Waste Operations and Emergency Response (HAZWOPER) training, plus appropriate 8-hour annual refresher training for all task participants. Supervisors must have completed additional 8 hours of HAZWOPER training. ALSO: Review of AHA during pre-task tailgate safety briefing with all intended task participants.</p> <p>PPE training in proper use, care, storage, and limitations. It is anticipated that this has been covered in employees' 40 hour HAZWOPER training, which is to be verified by the FOL/SSO through initial training documentation and review prior to permitting personnel to participate in site activities, and will be confirmed by visual observations of worker activities.</p>

ACTIVITY HAZARD ANALYSIS**Soil removal****Page 3 of 3**

I have read and understand this AHA:

Name (Printed)	Signature	Date



ACTIVITY HAZARD ANALYSIS (AHA)

Site Name: Atwater Facility

Task: Decontamination

Prepared by	J Carothers, PhD	Date	11/11	FOL	
Reviewed by	C. Snyder	Date	11/11	SSO	

TASK STEPS	HAZARDS	CRITICAL SAFETY PROCEDURES AND CONTROLS
Personal Decontamination <ul style="list-style-type: none"> Equipment drop Segregated removal of PPE (wash and rinse reusable items, dispose of non-reusable items) 	1. Slips, Trips, Falls 2. Exposure to contaminated media	1. Clear intended decontamination area location of roots, weeds, limbs and other ground hazards. Practice good housekeeping to keep the site clear of obstructions, materials, equipment and other tripping hazards. Wear appropriate foot protection to prevent slips and trips. Use caution when working on uneven and wet ground surfaces. 2. Follow good decontamination practices (work from top down and outside in). Nitrile gloves are to be the last item of PPE removed. Wash hands and face following personal decontamination and prior to performing any hand-to-mouth activity.
Decontamination of heavy equipment and large tooling (e.g., vehicles, etc.) using pressure washer	1. Noise 2. Flying projectiles 3. Falling objects 4. Strains/sprains from heavy lifting	1. Pressure washer operator must wear hearing protection (muffs or plugs with NRR of at least 25 dB) 2. Restrict other personnel from decontamination pad during pressure washing operations. Pressure washer operator must exercise care when directing the wand so that it is not pointing at himself/herself or at any other worker. Pressure washer operator must wear full face shield over safety glasses with side shields and brow protection. At FOL/SSO discretion, additional PPE consisting of hardhat, rain suit, apron, and or boot covers may be required during heavy equipment decontamination operations - depending on observations indicating that significant contact with decontamination overspray and/or windy conditions during washing activities. 3. Place items to be decontaminated on ground or on washing/drying racks in a manner that they are secure and will not fall. Wear safety toe safety footwear. 4. Practice safe lifting techniques (use mechanical lifting devices such as a dolly whenever possible, ensure clear path of travel, good grasp on object, perform "test lift" to gauge ability to safely make the lift, lift with

ACTIVITY HAZARD ANALYSIS

Decontamination

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TASK STEPS	HAZARDS	CRITICAL SAFETY PROCEDURES AND CONTROLS
	<p>5. Slips/trips/falls</p> <p>6. Exposure to contaminated media</p>	<p>legs not back, obtain help when needed to lift large, bulky, or heavy items).</p> <p>5. Keep areas orderly, maintain good housekeeping, spread light coating of sand on pad liner to increase traction.</p> <p>6. Follow good decontamination practices (work from top down and outside in). Surgeon's gloves are to be the last item of PPE removed. Wash hands and face following personal decontamination and prior to performing any hand-to-mouth activity.</p>
EQUIPMENT	INSPECTION	TRAINING
<p>Hand tools (hand brushes, garden sprayers, etc.)</p> <p>Pressure washer</p>	<p>Visual inspection prior to use by user. Check wooden handles for cracks or splinters.</p> <p>Inspect pressure washer prior to putting into service to ensure that it is in good working order, and ensure that fittings are secure.</p>	<p>None required.</p> <p>Review manufacturer's instructions and safety guidelines prior to use.</p>
<p>Personal Protective Equipment: Minimum: Safety toe boots, safety glasses Optional items: Hardhat, hearing protection. HTRW: Decontamination pad pressure washer operators are to wear full face shield over safety glasses with side shields and brow protection, hearing protection, and nitrile gloves. If contact with overspray cannot be avoided, rain suit or moisture-repellant disposable coveralls may be specified by the FOL/SSO.</p>	<p>Initial PPE inspection performed by FOL/SSO. Ongoing (prior to each use) inspections responsibilities of PPE users.</p>	<p>OSHA 40 Hazardous Waste Operations and Emergency Response (HAZWOPER) training, plus appropriate 8-hour annual refresher training for all task participants. Supervisors must have completed additional 8 hours of HAZWOPER training. Also Review of AHA during tailgate safety briefing with the intended task participants.</p> <p>PPE training in proper use, care, storage, and limitations. It is anticipated that this has been covered in employees' 40 hour HAZWOPER training, which is to be verified by the FOL/SSO through initial training documentation and review prior to permitting personnel to participate in site activities, and will be confirmed by visual observations of worker activities.</p>

ACTIVITY HAZARD ANALYSIS**Decontamination****Page 3 of 3**

I have read and understand this AHA:

Name (Printed)	Signature	Date



ACTIVITY HAZARD ANALYSIS (AHA)

Site Name: Atwater Facility

Task: IDW Management

Prepared by	J Carothers, PhD	Date	11/11	FOL	
Reviewed by	C. Snyder	Date	11/11	SSO	
TASK STEPS		HAZARDS		CONTROLS	
Filling, moving 55-gallon drums of IDW		<ol style="list-style-type: none"> 1. Heavy lifting 2. Struck by/pinches compressions 3. Falling objects (drums) 4. Slips, Trips, Falls 5. Foot hazards 6. Strains/sprains due to heavy lifting 7. Minor contusions, abrasions, cuts 		<ol style="list-style-type: none"> 1. Practice safe lifting techniques (use mechanical lifting devices such as a dolly whenever possible, ensure clear path of travel, good grasp on object, perform "test lift" to gauge ability to safely make the lift, lift with legs not back, obtain help when needed to lift large, bulky, or heavy items). 2. Exercise caution when handling drums. Position drums so that there is adequate room between them for placement and repositioning. 3. Do not stack drums on top of each other. Do not place more than 4 drums to a pallet. Leave at least 4 ft. of clearance between pallets for clear access. 4. Maintain good housekeeping in IDW storage areas, keeping it clear of loose debris and other potential tripping hazards. Wear appropriate foot protection to prevent slips and trips. Use caution when working on uneven and wet ground surfaces. 5. Safety toe foot protection will be required for IDW container handling activities. 6. Practice safe lifting techniques (use mechanical lifting devices such as a dolly whenever possible, ensure clear path of travel, good grasp on object, lift with legs not back, and obtain help when needed to lift large, bulky, or heavy items). 7. Wear cut-resistant gloves when handling items with sharp or rough edges. 	
EQUIPMENT		INSPECTION		TRAINING	
Hand tools (drum dollies, wrenches, etc.)		Visual inspection prior to use by user. Check wooden handles for cracks or splinters.		All personnel participating in this activity must be current with HAZWOPER training requirements.	
Personal Protective Equipment: Minimum: Safety toe boots, safety glasses Optional items: Hardhat, cotton or leather		Initial PPE inspection performed by FOL/SSO. Ongoing (prior to each use) inspections responsibilities of PPE		PPE training in proper use, care, storage, and limitations. It is anticipated that this has been covered in employees 40 hour HAZWOPER training, which is to be	

ACTIVITY HAZARD ANALYSIS**IDW Management**

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EQUIPMENT	INSPECTION	TRAINING
work gloves. HTRW: If contact with IDW is likely, wear chemical-resistant coveralls (e.g., Tyvek) or aprons and surgeon's nitrile gloves under leather/cotton work gloves.	users.	verified by the FOL/SSO through initial training documentation and review prior to permitting personnel to participate in site activities, and will be confirmed by visual observations of worker activities.

I have read and understand this AHA:

Name (Printed)	Signature	Date

ATTACHMENT IV

EQUIPMENT INSPECTION CHECKLIST

Heavy Equipment Inspection Checklist

Company: _____

Unit/Serial No#: _____

Inspection Date: ____ / ____ / ____

Time: ____ : ____

Equipment Type: _____
(e.g, earthmoving equipment - tractors backhoes, bulldozers, etc.)

Project Name: _____

Project No#: _____

Yes	No	NA	Requirements	Comments
<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>	Seat Belts <ul style="list-style-type: none"> Are available for intended operator and passengers (where applicable) Seat Belts are operational? 	
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Roll-Over Protection (ROPS) <ul style="list-style-type: none"> Roll-over protection structures (ROPS) are provided on vehicles and heavy equipment (including scrapers, tractors, loaders, bulldozers, carryalls, etc.) 	
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Brakes <ul style="list-style-type: none"> Brake systems capable of stopping and holding fully loaded equipment Parking Brake functions properly Wheel Chocks available (where and as applicable) 	
<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>	Access <ul style="list-style-type: none"> Non-slip steps Grab Handles (3-Point Grab/Step Mounting Points) 	

Heavy Equipment Inspection Checklist
Page 2

Unit/Serial No#: _____

Inspection Date: ____ / ____ / ____

Yes	No	NA	Requirements	Comments
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Audible Alarms <ul style="list-style-type: none"> Audible alarms –Bidirectional machines, such as rollers, compacters, front-end loaders, bulldozers, and similar equipment, shall be equipped with a horn, distinguishable from the surrounding noise level, which shall be operated as needed when the machine is moving in either direction. Back up Alarms –Self propelled equipment with an obstructed view to the rear will be equipped with a reverse gear signal alarm distinguishable from the surrounding noise level. Horn functioning properly 	
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Highway Use <ul style="list-style-type: none"> Fenders for equipment that can exceed 15mph Fire Extinguisher Are exhaust emissions directed away from the Operator? Cab <ul style="list-style-type: none"> Clean, free from debris, tools or equipment that can interfere with foot Control. Free from storage of flammable material/solvents Mirrors, Safety glass <ul style="list-style-type: none"> Equipped with defrosters Windshield wipers Turn signals, lights, brake lights, etc. (front/rear) for equipment approved for highway use? Gauges functioning properly Tires (Tread) or tracks Steering (standard and emergency) Are tools and material secured to prevent movement during transport? 	

Heavy Equipment Inspection Checklist
Page 3

Unit/Serial No#: _____

Inspection Date: ____ / ____ / ____

Yes	No	NA	Requirements	Comments
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Fluid Levels: <ul style="list-style-type: none"> • Engine oil • Transmission fluid • Brake fluid • Cooling system fluid • Hoses and belts • Hydraulic oil 	
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Fueling <ul style="list-style-type: none"> • Fueling of vehicles and heavy equipment is done with the engine off. • No smoking is permitted at or near the fuel storage or refueling area. A sign is posted stating: NO SMOKING WITHIN 50 FEET. • No sources of ignition are present near the fuel storage or refueling area. • A dry chemical or carbon dioxide fire extinguisher (rated 6:BC or larger) is in a location accessible to the fueling area, no closer than 50-feet. • Safety cans available? 	
<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Safety Guards – <ul style="list-style-type: none"> • Around rotating apparatus (belts, pulleys, sprockets, spindles, drums, flywheels, chains) the points of operations protected from accidental contact? • Hot pipes and surfaces are protected from accidental contact? • High pressure pneumatic lines have safety cable to prevent thrashing should it become disconnected? 	
<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>	Attachments <ul style="list-style-type: none"> • Have the attachments designed for use (as per manufacturer's recommendation) with this equipment been inspected and are considered suitable for use? 	

Heavy Equipment Inspection Checklist
Page 4

Unit/Serial No#: _____

Inspection Date: ____/____/____

Yes	No	NA	Requirements	Comments
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Operator Qualifications <ul style="list-style-type: none"> Does the operator have proper licensing where applicable, (e.g., CDL)? Does the operator, understand the equipment's operating instructions? Is the operator experienced with this equipment? Is the operator 21 years of age or more? 	
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	PPE Required <ul style="list-style-type: none"> Hardhat Safety glasses Work gloves Chemical resistant gloves _____ Steel toed Work Boots Chemical resistant Boot Covers Apron Coveralls Tyvek, Saranex, cotton) _____ 	
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Key(s)?	
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Operating Manual?	
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Other Hazards <ul style="list-style-type: none"> Excessive Noise Levels _____ dBA Chemical hazards (Drilling supplies - Sand, bentonite, grout, fuel, etc.) - MSDSs available? 	

Approved for Use ☐ Yes ☐ No ☐ See Comments

Site Health and Safety Officer

Operator

ATTACHMENT V
SAFE BOATING CHECKLIST

TETRA TECH, INC.
SAFE BOATING CHECKLIST

Owner/Operator Name: _____

Registration Number _____

Location _____ **County:** _____ **State:** _____ **HIN:** _____

Length of Boat: <16 ☐ 16-25 ☐ 26-39 ☐ 40-65 ☐ > 65 ☐

Area of Operations: Inland ☐ Coastal ☐

Powered by: Gas ☐ Diesel ☐ Sail ☐ Other ☐

Type: PWC ☐ Open ☐ Cabin ☐ Other ☐

VESSEL SAFETY CHECK REQUIREMENTS				RECOMMENDED AND DISCUSSION ITEMS			
Item	Yes	No	NA	Item	Yes	No	NA
1. Display of Numbers				(While encouraged, items below are not requirements)			
2. Registration / Documentation				I. Marine Radio			
3. Personal Flotation Devices (PFD)				II. Dewatering Device & Backup			
4. Visual Distress Signals (VDS)				III. Mounted Fire Extinguishers			
5. Fire Extinguishers				IV. Anchor & Line for Area			
6. Ventilation				V. First Aid and PIW Kits (**over)			
7. Backfire Flame Control				VI. Inland Visual Distress Signals			
8. Sound Producing Devices / Bell				VII. Capacity / Cert. of Compliance			
9. Navigation Lights				VIII. Discussion Items: (as applies)			
10. Pollution Placard				a. Accident reporting/owner responsibility			
11. MARPOL Trash Placard				b. Offshore operations			
12. Marine Sanitation Devices				c. Nautical charts / navigation aids			
13. Navigation Rules				d. Survival tips / first Aid			
14. State and/ or Local Requirements				e. Fueling / fuel management			
15. Overall Vessel Condition:				f. Float plan / weather & sea conditions			
a. Deck free of hazards / clean bilge				g. Insurance considerations			
b. Electrical / fuel systems				h. Boating check list			
c. Galley / heating systems				i. Safe boating classes			

This checklist has been modified for use from the United States Coast Guard Auxiliary Vessel Safety Check (VSC) Program. USCG AUX. Form 204 (7-2000)

Explanation of Required Items

- ☐ **1. NUMBERING:** The boat's registration number must be permanently attached to each side of the forward half of the boat. Characters must be plain, vertical, block style, not less than three (3) inches high, and in a color contrasting with the background. A space or hyphen must separate the letters from the numbers.
- ☐ **2. REGISTRATION / DOCUMENTATION:** Registration or Documentation papers must be on board and available. Documentation numbers must be permanently marked on a visible part of the interior structure. The documented boat's name and hailing port must be displayed on the exterior hull in letters not less than 4 inches in height.
- ☐ **3. PERSONAL FLOTATION DEVICES (PFDs):** Acceptable PFDs (also known as Life Jackets) must be U.S. Coast Guard approved and in good, serviceable condition. A wearable PFD of suitable size is required for each person on the boat. Wearable PFDs shall be "*readily accessible*." Boats 16 feet or longer, must also have one Type IV (throwable) device, which shall be "*immediately available*." PFDs shall NOT be stored in unopened plastic packaging.
- ☐ **4. VISUAL DISTRESS SIGNALS:** Boats 16 feet and over are required to carry a minimum of either:
- 1) three day and three night pyrotechnic devices
 - 2) one day non-pyrotechnic device (flag) and one night non-pyrotechnic device (auto SOS light)
 - 3) a combination of 1) and 2).
- Boats less than 16 feet need only carry night visual distress signals when operating from sunset to sunrise. It is recommended, but not required, that boats operating on inland waters should have some means of making a suitable day and night distress signal. The number and type of signals is best judged by considering conditions under which the boat will be operating.
- ☐ **5. FIRE EXTINGUISHERS:** Fire extinguishers are required if one of the following conditions exists:
- 1) Inboard engine(s)
 - 2) Double bottom hulls not completely sealed or not completely filled with flotation materials
 - 3) Closed living space
 - 4) Closed stowage compartments that contain flammable materials or
 - 5) Permanently installed fuel tanks. Boats less than 26 feet, and propelled by outboard motors are NOT required to have fire extinguishers unless one or more of the conditions (2-5) listed above applies.

Coast Guard Classification of Fire Extinguishers		
Classification (type size)	B-I	B-II
Foam (minimum gallons)	1.25	2.5
Carbon Dioxide (minimum lbs.)	4	15
Dry Chemical (minimum lbs.)	2	10
Halon (minimum lbs.)	2.5	10

NOTE: Fire extinguishers must be readily accessible and verified as serviceable.

MINIMUM NUMBER OF EXTINGUISHERS REQUIRED		
Boat Length	No Fixed System	With Fixed System
Less than 26'	one B-1	0
26' to less than 40'	two B-1 or one B-2	one B-1
40' to 65'	three B-1 or one B-1 & one B-2	two B-1 or one B-2

- ❑ **6. VENTILATION:** Boats with gasoline engines in closed compartments, built after 1 August 1980 must have a powered ventilation system. Those built prior to that date must have natural or powered ventilation. Boats with closed fuel tank compartments built after 1 August 1978 must meet requirements by displaying a "certificate of compliance." Boats built before that date must have either natural or powered ventilation in the fuel tank compartment.
- ❑ **7. BACKFIRE FLAME ARRESTER:** All gasoline powered inboard/outboard or inboard motor boats must be equipped with an approved backfire flame control device.
- ❑ **8. SOUND PRODUCING DEVICES:** To comply with Navigation Rules and for distress signaling purposes all boats must carry a sound producing device (whistle, horn, siren, etc.) capable of a 4-second blast audible for ½ mile. Boats larger than 39.4 ft. are also required to have a bell (see Navigation Rules.)
- ❑ **9. NAVIGATION LIGHTS:** All boats must be able to display navigation lights between sunset and sunrise and in conditions of reduced visibility. Boats 16 feet or more in length must have properly installed, working navigation lights and an all-around anchor light capable of being lit independently from the red/green/white "running" lights.
- ❑ **10. POLLUTION PLACARD:** Boats 26 feet and over with a machinery compartment must display an oily waste "pollution" placard.
- ❑ **11. MARPOL TRASH PLACARD:** Boats 26 feet and over in length, operating in U.S. navigable waters, must display a "MARPOL" trash placard. Oceangoing boats 40 feet and over must also have a written trash disposal plan available onboard.
- ❑ **12. MARINE SANITATION DEVICE:** Any installed toilet must be a Coast Guard approved device. Overboard discharge outlets must be capable of being sealed.
- ❑ **13. NAVIGATION RULES:** Boats 39.4 feet and over must have on board a current copy of the Navigation Rules.
- ❑ **14. STATE AND LOCAL REQUIREMENTS:** A boat must meet the requirements of the state in which it is being examined.
- ❑ **15. OVERALL BOAT CONDITION: As it applies to this Vessel. Including, but not limited to:**

a. Deck free of hazards and clean bilge - The boat must be free from fire hazards, in good overall condition, with bilges reasonably clean and visible hull structure generally sound. The use of automobile parts on boat engines is not acceptable. The engine horsepower must not exceed that shown on the capacity plate.

b. Electrical and Fuel Systems: The electrical system must be protected by fuses or manual reset circuit breakers. Switches and fuse panels must be protected from rain or water spray. Wiring must be in good condition, properly installed and with no exposed areas or deteriorated insulation. Batteries must be secured and terminals covered to prevent accidental arcing. If installed, self-circling or kill switch mechanism must be in proper working order.

Fuel Systems - Portable fuel tanks (normally 7 gallon capacity or less) must be constructed of non-breakable material and free of corrosion and leaks. All vents must be capable of being closed. The tank must be secured and have a vapor-tight, leak-proof cap. Each permanent fuel tank must be properly ventilated.

c. Galley and Heating Systems - System and fuel tanks must be properly secured with no flammable materials nearby.

ATTACHMENT VI

OHSA POSTER

Job Safety and Health

It's the law!

EMPLOYEES:

- You have the right to notify your employer or OSHA about workplace hazards. You may ask OSHA to keep your name confidential.
- You have the right to request an OSHA inspection if you believe that there are unsafe and unhealthful conditions in your workplace. You or your representative may participate in that inspection.
- You can file a complaint with OSHA within 30 days of retaliation or discrimination by your employer for making safety and health complaints or for exercising your rights under the *OSH Act*.
- You have the right to see OSHA citations issued to your employer. Your employer must post the citations at or near the place of the alleged violations.
- Your employer must correct workplace hazards by the date indicated on the citation and must certify that these hazards have been reduced or eliminated.
- You have the right to copies of your medical records and records of your exposures to toxic and harmful substances or conditions.
- Your employer must post this notice in your workplace.
- You must comply with all occupational safety and health standards issued under the *OSH Act* that apply to your own actions and conduct on the job.

EMPLOYERS:

- You must furnish your employees a place of employment free from recognized hazards.
- You must comply with the occupational safety and health standards issued under the *OSH Act*.

**This free poster available from OSHA –
The Best Resource for Safety and Health**



**Occupational Safety
and Health Administration**
U.S. Department of Labor



Free assistance in identifying and correcting hazards or complying with standards is available to employers, without citation or penalty, through OSHA-supported consultation programs in each state.

1-800-321-OSHA
www.osha.gov

OSHA 3165-12-06R

**H M Environmental Services Inc.
42826 N. Walnut
Mt. Clemens, MI 48043**

**Health and Site Safety Plan
For
CONTAMINATED SOIL REMEDIATION PROJECT
AND SITE RESTORATION**

**United States Coast Guard
Atwater Site Detroit Michigan**

**Prepared By:
Steven H. Matthes**

**Date:
11-14-11**

***Challenging today's Environmental Issues
With Tomorrows Solutions***

**H M Environmental Services Inc.
Site Health and Safety Plan**

Outline

- 1. Project Description**
 - 2. Work Performed By**
 - 3. Job Scope**
 - 4. Site Address**
 - 5. Contact Personnel:**
 - 6. Facility Description**
 - 7. Hazardous and Materials Description:**
 - 8. Decontamination Procedures**
 - 9. Personal Protective Equipment**
 - 10. Emergency Telephone List , Directions to Hospital**
 - 11. Work Scope:**
 - 12. Team Organization**
 - 13. Hazard Communication Program**
- B. Material Safety Data Sheets**

Site Safety Plan
H M Environmental Services Inc.

1. **Project:** Soil Remediation USCG Atwater Street Detroit, Michigan
2. **Work Performed By:** HM Environmental Services Inc.
3. **Job Scope:** Remove debris and concrete piles, scrap steel tank, remove concrete surface, excavate non-hazardous soils, Backfill and site restoration
4. **Site Address:** Atwater Street, Detroit Michigan
5. **Contact Personnel:**
Tetra Tech
Joe Logan

HM Environmental Services Inc.
Office (586)469-0041 Fax (586)460-1014
Dennis Heine Project Manager (586)469-0041 Cell (586)413-0070
Joseph Heine (586)469-0041 Cell (586)413-1111
Warren Wrotham
Misc Drivers
6. **Facility Description:** Vacant river front property
7. **Hazardous Materials Descriptions: (NON-HAZARDOUS SOILS)**
 - A. Liquid___ Solid__X___ Sludge_____ Vapor/Gas__ ___
 - B. Chemical Name/Class: Contaminated Soils with gasoline
 - C. Characteristics: Corrosive_____ Ignitable_____ Volatile___Metals__X__
 - D. Toxicity: Refer to MSDS'S
 - E. Special Hazards: Use proper safety equipment when handling contaminated materials, materials are designated as Non-hazardous avoid spilling when loading transportation vehicles. Use safety precautions when working on site from slip, trips, falls open excavations and wet soils.

Concrete Materials use caution when handling, use caution of sharp objects and nails, screws, wood splinters when handling. Avoid dust from materials if required apply water to reduce dust. Load materials into designated vehicles for disposal.

- F. Acute Exposure Syptoms: Stomach Ache, Head ache refer to MSDS for Further information. Eye irritation wear appropriate safety gear.

G. Routes of Exposure: Skin X
Ingestion X Inhalation X

- H. Hazard Level: High _____ Moderate _____ Low X
Unknown _____

- I. Physical hazard of site: (Taken to account, operational concerns, reactivity, decontamination, stability, flammability, etc.) Use of level “C” when in a confined area for airborne materials. Level D for all other work procedures as work scope calls for. If a potential hazard accurse while completing specified tasks stop work and address proper procedures with on-sight supervisor. Use caution when completing demo procedures of personnel, structures, equipment and the site.

8. Decontamition Procedures:

LEVEL A - Segregate equipment, drop boot covers and wash gloves. Remove tape, remove outer gloves, outer suit. Remove hard hat, SCBA, backpack, inner gloves, inner protective coveralls. Conduct field wash and redress.

LEVEL B - Segregate equipment, drop boot covers and wash gloves. Remove tape and outer gloves, SCBA, suit, hard hat, inner gloves, field wash and redress.

LEVEL C - Segregate equipment, drop boot covers and wash gloves, remove boot covers, outer gloves, (canister or mask removal), safety boot removal, suit removal, inner glove removal, field wash, redress.

LEVEL D - Segregate equipment, boot and glove drop, wash hands and face In designated facility.

9. **Personal Protective Equipment:**

A. Entry level of protection A_____ B_____ C_____ D X

Modifications: Wear Hard Hats, Safety Glass's, Protective Boots, Gloves

B. Respiratory protection equipment:

SCBA_____ Full Face Respirator_____ Cartridge Type_____
Half Face Respirator X Cartridge Type_____

C. Protective Clothing:

LEVEL A - should be worn when the highest level of respiratory, skin,eye, and mucas membrane protection is needed.

_____ Positive - Pressure (Pressure demand), SCBA (MIOSHA/NIOSH)
(REQUIRED)

_____ Fully encapsulated chemical resistant suit. (REQUIRED)

_____ Gloves, inner, chemical resistant. (REQUIRED)

_____ Gloves, outer, chemical resistant. (REQUIRED)

_____ Boots, chemical resistant, steel toed and shank. (REQUIRED)

_____ Hard hat (REQUIRED)

_____ Coveralls (under suit)

_____ Two-way Radio communication

LEVEL B protection should be selected when the highest level of respiratory protection is needed, but a lesser level of skin and eye protection. LEVEL B protection is the minimum level recommended on initial site entry until the hazards

have been further identified and defined by monitoring, sampling, and other reliable methods of analysis.

_____ Positive - Pressure (pressure demand), SCBA (MIOSHA/NIOSH approved)
(REQUIRED)

_____ Chemical resistant clothing (overalls, jacket overalls, hooded two piece chemical splash suit, disposable chemical resistant) (REQUIRED)

_____ Coveralls (under splash suit)

_____ Boots, inner, chemical resistant, steel toe & shank (REQUIRED)

_____ Boots, outer, chemical resistant

_____ Hard hat

_____ Two-way radio communications.

LEVEL C protection should be selected when a type of airborne substance is known.

_____ Full face, air purifying respirator (MIOsha/NIOSH approved)
(REQUIRED)

_____ Chemical resistant clothing (one piece coverall, hooded two piece chemical splash suit, chemical resistant hood and apron, disposable chemical resistant coveralls) (REQUIRED)

_____ Gloves, outer, chemical resistant (REQUIRED)

_____ Gloves, inner, chemical resistant (REQUIRED)

_____ Boots, Steel toe and shank, chemical resistant (REQUIRED)

_____ Cloth coveralls (inside chemical protective clothing)

_____ Two-way radio communications

_____ Hard hat

LEVEL D is primarily a work uniform. It should not be worn on any site where respiratory or skin hazards exist.

 X Face Shield on Hard Hat when Air Knifing

 X Safety glasses

 X Hard hat

 X Steel toed and steel shank boots

 X Reflective Safety Vest

 X Work Gloves

10. Emergency Telephone List Directions to Hospital

The project Foreman and each group coordinator be equipped with an emergency Notification devise or by voice to alert all work crew members in case of an emergency situation.

Emergency notification will be two short blasts with a horn in repeated intervals of (5) seconds. Upon hearing the emergency notification, the project Foreman and group coordinator(s) will direct all personnel to a pre-determined Safe Zone. The Project Foreman will be responsible for coordinating any necessary first aid procedures and implementing any other required emergency action.

Emergency Telephone List

Detroit Receiving Hospital

4201 St. Antoine Blvd.

Detroit, MI (313) 745-3000

Fire 911

Police 911

Ambulance 911

Hospital 911

Directions to Hospital

See attached map for directions to hospital at back of Hasp w/attachments

Non – Emergency Hospital # above.

National Poison Control Center

Chemtrec

1-800-424-9300

In the event of an accidental or intentional release of “Hazardous Substance” in a reportable quantity, the person in charge shall notify:

U. S. Coast Guard - National Response Center: 1-800-424-8802

State Notification:

PEAS

Michigan DNR Pollution Emergency Alert:

In Michigan	1-800-292-4706
Outside Michigan	1-517-373-7660
Ohio	1-800-282-9378
Indiana	1-317-633-0144
Illinois	1-217-782-7860
Wisconsin	1-608-266-3232

U. S. Department of Transportation	1-202-426-1830
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11. Work Scope

Definition of Work Scope tasks use as a guiding reference, changes may be made:

Task 1 – Discuss H.A.S.P. with all on-site personnel, notify all personnel on-site of daily activities. Complete tail gate meetings every morning to discuss daily objectives.

Task 2 – Conduct facility inspection prior to work commencing, insure utilities are located, disconnected if applicable and safe, (electricity is disconnected and or any other dangers are inspected before starting any work.

Task 3 – Set up work areas for proper ventilation and collection of materials. Install pedestrian barrier/snow fence/sediment control, caution tape if required.

Task 4 – Begin removal debris piles and scrap the steel tank

Task 5 – break and remove concrete over impacted soils. Transport concrete to concrete recycler

Task 6 – Identify underground utilities and be sure power is off and tagged out at the control panel as required. Expose and cut conduits at the edge of the excavation limits.

Task 7 – Remove impacted soils with proper sloping of the excavation. Load , transport and dispose of soils at Veolia landfill Northville, MI

Task 8 – Backfill and compact imported class II sand.

Task 9 – Site restoration

12. Team Organization

Personnel (In order of chain of command)

Name	Function/Title	Company
Joseph Heine	Project Suprv.	HM Env.
Warren Worthem	Field Tech	HM Env.
Misc.	Field Tech	HM Env.
Misc.	Equipment Tech	HM Env.

13. Hazard Communication Program

Field Operational Chemical List for:

PROJECT: USCG Atwater Street Detroit MI

Contaminated Soils

1. PAHs
2. Arsenic
3. Lead

Verification that each person has read and understands this Health and Safety Plan. Also, the Hazards associated with the information stated in this Site Safety Plan.

By signing this Form, I agree to abide by all safety requirements
As outlined above.

Name (print)

Signature

Date[illegible]